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EXPERIMENTATION
IN
CONTROLLED ENVIRONMENT

Edited by: C.G. MILES

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EXPERIMENTATION
IN
CONTROLLED ENVIRONMENT

Its Implications for Economic Behaviour and Social Policy Making

Edited by C. G. MILES

General Editor: S. L. LAMBERT

ALCOHOLISM AND DRUG
ADDICTION RESEARCH FOUNDATION
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Introduction

The idea for this Symposium had its origin in the specific problems and practical difficulties encountered by researchers at the Addiction Research Foundation of Ontario, in an attempt to plan an appropriate experimental format for the study of the subchronic effects of daily cannabis smoking on human behaviour. As the research weaknesses in the procedures which had been developed became increasingly apparent, correspondingly the evidence became clearer that the particular problems were not the unique preserve of a single, specific discipline. They demanded to be studied in the broader context provided by other disciplines bearing on the same problems.

One of the main thrusts of the work with cannabis was an examination of the effects of habitual smoking on social, economic, psychological, spending, and saving behaviour. The aim was to create as natural a controlled environment as possible and to reproduce experimentally the 'amotivational syndrome' in 'normal' cannabis smokers. Volunteer subjects who did assigned jobs for pay lived under tight security conditions where their behaviour could be observed and recorded 24 hours a day, for anything from 70 to 98 days. This was a departure from previous research in three respects. It represented one of few long-term studies in the field. Unlike 'token economy' experiments, where subjects are patients or prisoners and modification of behaviour was a partial purpose of the experiment, these were volunteers and the only aim was to observe drug effects. For the former, tokens were the medium of exchange, for the latter, currency equivalent. From these beginnings, the experimental 'micro-economy' came into existence.

It was in order to examine the problems in controlled environment research, now known to demand the specialized knowledge of interrelated disciplines, that this Symposium was convened. The eleven papers by a group of researchers with a variety of expertise and experience in dealing with the many facets of human behaviour, represent the fields of experimental psychology, economics, psychiatry, statistics, ecology, architecture, clinical psychology, pharmacology, animal behaviour and anthropology.

A main focus in the Symposium was on the 'normal' subjects in controlled environment research. All disciplines were in agreement that this may offer answers to the critical questions being raised. It was of particular interest to the econometricians who traditionally work with mathematical models which use axiomatic statements about behavioural and psychology variables. These are often either at variance with the known facts or would be amenable to empirical investigation. The view of the economists was that closed economic systems exemplified by the micro-economy and token economy approaches would be valuable in providing data on productivity, earnings, spending patterns, savings and consumer preferences. In the behaviour of the drug user, all these areas are pertinent.

The epidemiologists' concerns with the prevalence of alcoholism and its relation to price and level of acceptance were considered useful guides to future experimentation about changes in drinking habits on an individual basis. Their research demonstrated that, in societies where the price of alcohol is high and the acceptance of drinking behaviour is low, the indices which show the amount of excessive drinking, also indicate the rate of alcoholism. It is clear that economic factors are important but the epidemiological breakthrough in this area does not allow us to predict the individual case. Utilizing the knowledge and tools of all related disciplines, experimentation in the controlled environment where many extraneous factors can be excluded, could provide the data to test the epidemiologists' hypotheses. It was speculated that an interesting experiment in a micro-economy community would be to make the most widely-used recreational drugs, for example alcohol, available to subjects, at systematically varied prices. If the price of alcohol were very high, and the price of cannabis low, would alcoholics switch to cannabis and under what conditions? What would be the effect of such a switch on the behaviour and production of the subjects? Answers to these questions could have profound consequences for social and treatment policies.

Participants in the Symposium recognized that underlying all the discussions was the creation of a new interdisciplinary approach which could be called behavioural economics, a collaboration of specialists in various disciplines rather than the development of a new field.

Present token economic systems and their aim to modify the behaviour of psychiatric patients and alcoholics were carefully scrutinized. Their increasing use as management procedures simply to serve the needs of the institution, rather than as therapy or research measures, was questioned and indeed condemned by all participants. The term 'economy' was discussed and the use of tokens as rewards and as a substitute for money which could purchase privileges and sometimes goods. The general observation was that economic analysis of such systems was neglected, and that because psychologists were too little aware of the economic aspects, inflationary, deflationary and oversaving situations developed. This critical appraisal emphasized the importance of the marriage of 'economics' and psychology and the contribution the two could make toward understanding behavioural economics in comparison with real economics.

A major area of discussion dealt with the inevitable question, to what extent can results from controlled experiment research be generalized? Have they potential implications for the social scene? The proceedings of the conference themselves were a partial answer. Agreements were made to pool resources, ideas and concepts on a continuing basis with a hope that the use of behavioural economics experiments would enable social policy makers to try out some ideas in controlled environments before changing legislation.

C. G. Miles

Acknowledgement

Since several of the papers in this volume make reference to, and describe research which arose from, an experimental project undertaken at the Addiction Research Foundation, it was thought advisable for the sake of clarity and convenience to include the original report of the study. The monograph which follows was circulated as supplement 1 to volume 34 (1974) of *Acta Pharmacologica et Toxicologica.* It is reproduced here in its original form by kind permission of the editors.

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An Experimental Study of the Effects of Daily Cannabis Smoking on Behaviour Patterns

By

C. G. MILES, G. R. S. CONGREVE,
R. J. GIBBINS, J. MARSHMAN,
P. DEVENYI and R. C. HICKS

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P. DEVENYI and R. C. HICKS

MUNKSGAARD COPENHAGEN, 1974

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Abstract

Six male volunteer subjects were studied for 70 days in a high security hospital setting under a token economic (micro-economic) system. A 42-day regimen of free purchase and compulsory marijuana smoking was established, using one gram cigarettes with 8.5 mg $\triangle^9$-THC. This period was preceded and followed by two weeks when marijuana was not available. Subjects were paid only for goods produced. Earnings could be saved or spent to satisfy subjects' needs and consumer desires. All economic transactions were recorded. Data was collected every half hour of each subject's dominant activity. The subjects demanded, and recieved, two wage raises. Introduction of cannabis resulted in lower productivity; reduction of intake raised productivity. A fall in productivity was matched by a fall in time spent working, but not in efficiency. Subjects spent more time resting awake and in entertainment during periods when more marijuana was smoked. Some indications of "amotivational syndrome" were present but no evidence of physiological damage was yielded by clinical medical examinations. Certain relationships between alcohol and marijuana were noted.

Introduction

Cannabis is already a drug used by a substantial minority in many parts of the world (WHO Technical Report No. 478, 1971). The extent to which it is used would certainly increase if recommendations such as those made in Canada by the Cannabis Report of the Commission of Inquiry into the Non-Medical Use of drugs (1972) -- hereafter referred to as the Canadian Cannabis Report -- were put into effect. Most studies of cannabis smoking have been either experimental studies of the acute effects, epidemiological surveys or clinical reports. Each approach contributes in its unique way to the growth of our knowledge of the drug and its effects, but it is the case that we are ignorant of the long term effects of regular cannabis consumption, uncomplicated by the use of other drugs, on both individuals and society.

Definite answers to many of the questions about cannabis can be achieved only by large scale, long term studies of the kind that revealed the harmful effects of tobacco and alcohol. For the investigation of some drugs there is potential for using a form of anthropological field technique in which individuals record their consumption of the drug and its effects. The problems with this type of approach are obvious and related to the difficulty of recording and describing accurately all aspects of the conditions. When the drug in question is illicit, of variable quality, associated with a particular lifestyle and frequently used in conjunction with other drugs, the administrative, legal and ethical problems become almost insurmountable. Practical and ethical constraints rule out extremely long term studies under controlled conditions. It is not surprising therefore that few investigators have confronted the problems of studying experimentally the long term effects of regular cannabis consumption. A few have sought a compromise in studying the "subchronic" *(Canadian Cannabis Report, 1972)* effects, e.g., WILLIAMS *et al.* (1946); *Mayor's Report* (1944). In the present study the drug is administered in known quantities in controlled conditions for a period of weeks -- clearly not long enough to reveal effects of the lung cancer/cigarette smoking variety, but hopefully long enough to study some important questions.

Many sociological and clinical reports described an "amotivational syndrome" (MCGLOTHLIN & WEST, 1968) referring to a pattern of symptoms among which were social and economic deterioration. An experimental method was developed which simulated some aspects of earning, spending, and saving behaviour in a controlled social environment. It was hoped this method would enable us to assess the effects of the drug on some aspects of social and economic behaviour.

It should be noted here that the amotivational syndrome as defined by McGlothlin & West (1968) refers to "characteristic personality changes" which may occur as a result of regular long term use of marijuana. Whether these suggested long term changes can be attributed to the effects on behaviour of regular acute intoxication or whether they are permanent long term effects which persist beyond the period of cannabis use is still a matter for speculation. One point at issue for the present experiment is whether the behaviour described denoting amotivational syndrome can be produced or enhanced in subjects claiming to be regular users when subjected to intoxicating doses of cannabis daily for a relatively short period of time. Data from long term follow up investigations of the same subjects may shed further light on the persistence of any such effects. We may therefore acquire information which will suggest a redefinition or qualification of the amotivational syndrome.

In developing a suitable methodology we were influenced by the thinking of Skinner (1938). The practice of rewarding the responses of animals according to a pre-arranged schedule of reinforcement and then observing the effect of a drug on the organism's behaviour is a well established method of investigating acute and chronic drug effects (Dews & Morse, 1961; Schuster & Zimmerman, 1961). The use of similar techniques of investigating drug effects on humans is also practiced but, to date, almost exclusively to study acute effects (e.g., Cappell *et al.,* 1972).

The search for an appropriate experimental methodology in the existing literature of the relevant disciplines proved to be disappointing. The most promising experimental framework reported in the literature seemed to be that called the "token economy" (Ayllon & Azrin, 1968). This particular approach based on operant conditioning theory (Skinner, 1953) depends on the rewarding of relevant responses which are spontaneously emitted by the organism under particular environmental conditions. The efficacy of the reward (reinforcement) is judged by the extent to which the selected or "target" behaviour will be emitted under similar environmental conditions. This approach has been used successfully in modifying the behaviour of individuals under psychiatric care, school children, prison populations, etc. The extent to which this approach has been seuccessful in achieving its aims is considerable. The literature has been critically reviewed by Kazdin & Bootzin (1972).

After careful consideration the usual "token economy" method seemed to be not entirely appropriate because of the nature of the population and behaviours to be studied in this experiment, i.e., working, earning, spending, saving, drug taking and other behaviour patterns in volunteer subjects. It followed therefore that the experimental conditions should be constructed so that the behaviour of the subjects is minimally constrained given the qualification of a closed experimental situation. The optimal experimental design indicated therefore was one in which the subject saw himself as actually doing a job rather than as a patient or serving only in the capacity of experimental subject. The conditions should reflect a small closed society in which an individual production process took place, a saleable product was produced, the product was paid for and subjects' needs and consumer desires were satisfied by the expenditure of effort in the production process, which could in turn be translated into an easily negotiable means of exchange such as money. For varlous reasons to be explained later, money was not actually used but tokens with real currency exchange value. As few limitations as possible were placed on what the simultated currency could be exchanged for.

The whole theory and practice of this approach is being prepared for more extensive reporting elsewhere (Miles & Congreve, 1974). However, it may be useful to outline some of the ways in which the "micro-economic" methodology we have developed is theoretically and operationally distinct from the "token-economy" of Ayllon & Azrin (1968). The aim of the "token-economy" is always to modify individual behaviour which contrasts with the aim of the "micro-economy". The obvious practical difference is that our subjects were "normal" volunteers. Token economies have generally been inhabited by psychiatric patients, disturbed, retarded, or delinquent children or some other "captive" group. The micro-economy was designed to attach monetary advantages to remaining in the experiment (a contract was signed by all subjects prior to their participation) but the experimenters had no other sanctions should the subjects decide to leave. The subjects were selected on the basis of psychiatric stability and non-criminal activities other than their admitted use of cannabis.

Theoretically, token-economies are designed to modify or establish certain "target behaviours" in individuals. There is no selection of individual (or group) target behaviours in the micro-economy, which is designed to permit as wide a range of behaviours as possible. Furthermore, in a token-economy, reinforcement is made available through the medium of tokens in the shape of preferred goods or services. Earning capacity is, or should be, related to preference and "price" of individually determined reinforcers to maximize behaviour change (Winkler, 1971). In a micro-economy only one behaviour is "reinforced" by monetary payment (i.e., production) and the object of the economy is to assess motivation and preference in terms of overt economic and social behaviour. If behaviour changes, it does so because of individual preferences or group norms, not because of an imposed “engineering”.

It is also implied in token-economies that certain behaviours are deemed “adaptive” or “acceptable” to staff. While micro-economies will obviously contain norms of an analogous kind, they would as far as possible originate in the individual and a peer group of subjects.

It follows that the critical independent variable in this situation was the introduction of cannabis and the attendant conditions. While in theory any of the economic or social conditions described could be varied systematically and investigated within a micro-economy, the concern here was, as far as possible, to hold these conditions constant and to measure social and economic behaviour as comprehensively as possible. This shotgun approach seemed justifiable in view of the lack of reliable data on the variables affected by cannabis in this type of situation. We felt that the micro-economy was a unique social and economic environment which reflected some of the characteristics of the “real world” but, more importantly, provided an experimental situation in which accurate baseline and drug-phase data could be collected from a functioning community. In other words, the micro-economy was felt to be a useful compromise between scientific rigour and natural conditions which, in the investigation of drug effects, could in some measure fill the gap between animal and acute human studies and clinical papers.

Since the study was not primarily designed to investigate physiological and biochemical effects of cannabis, medical investigations were originally to be confined to screening of subjects, taking care of their health needs during their stay and guarding them against potentially harmful effects. Nevertheless it was recognized that useful physiological and biochemical measurements can be made parallel to the psycho-social and behavioural ones without interfering with the main objectives of the study.

A further aim of the study was the development and application of techniques for the detection and measurement of cannabis compounds or their metabolites in urine and blood.

Method

Accommodation

The experiment was housed on the third floor of a detached annex to a larger hospital. The unit had independent kitchen, housekeeping and security services, and also had a medical laboratory and x-ray, ECG and EEG facilities.

The third floor accommodation was arranged along either side of a wide North-South corridor. From North to South along the West side it ran as follows:

(1) A recreation room, containing a ping pong table, exercise bicycle and gym mats.
(2) A workroom, containing small tables and upright chairs.
(3) A washroom connecting (2) and (4). The showers in this area were disconnected to facilitate collection of payment for showering.
(4) A six bed bedroom.
(5) A TV lounge. Access for the TV lounge was from a sun-lounge at the South end of the corridor.
(6) A lounge containing a stereo record-player, opposite the TV lounge.
(7) A washroom with functional showers.
(8) An office used by a research assistant.
(9) The store, containing cupboards, countertop and a refrigerator.
(10) A staff lounge.
(11) A small kitchen and dispensary.
(12) Opposite the recreation room, the nursing station.

The area was well decorated, light, airy and spacious, but quite clearly a hospital floor.

Security

The doors at the North end and the East side of the South end of the corridor were locked. The locks were automatically released by the fire alarm. Access to the ward, forbidden to all the staff not working directly on the study, was by the North door which was operated by a buzzer system from the Nursing station. All windows were equipped with both screen and storm windows. The security arrangements were substantially successful in excluding intruders and containing the subjects.

Staff and staff training

The staff of the experiment consisted of two behavioural scientists (psychologists), one physician, one psychiatrist, one social worker and a full shift complement of registered nurses and attendants. Most of the nurses and attendants had worked previously in the medical care and rehabilitation of patients with alcohol or drug dependence. A full medical back-up and laboratory service was also provided.

It was intended that the staff should influence the behaviour of the subjects as little as possible. They were made familiar, in a two week course of lectures and films, with techniques of behaviour modification and therapy, with particular emphasis on social reinforcements as agents of behavioural change. They were then instructed to avoid, as far as humanly possible, social contacts with the subjects which could influence behaviour -- their own or the subjects'. The staff were to adopt a "non-involvement role" in which they would not respond, positively or negatively, to social interactions, and would not indicate approval or disapproval of the subjects' behaviour. The staff were to collect data, and to maintain the security and the conditions of the experiment. All ward staff dressed in street clothes throughout the experiment.

In a pre-pilot phase of the experiment, four two-week long experiments were run, in which the experimental conditions progressively approximated the full micro-economy and data collection situation envisaged for the cannabis study. The subjects were recently detoxified alcoholics, and the experiments served the incidental purpose of providing a short term rehabilitation service as well as the main aim of provoding practice and experience for staff. The data from these experiments are themselves interesting and will be reported at a later date.

The setting of the micro-economy

The central aim of the study was the collection of data on the social and economic behaviour of the subjects. It was felt that these behaviours would be particularly sensitive to distortion from social reinforcement by the ward staff, hence the non-involvement role. It was also felt that frequent medical, psychiatric and psychological investigation would encourage the subjects to see themselves as "patients" and might systematically distort the data. Investigations parallel to the main aims were therefore kept to a minimum that was consistent with good medical care.

The experimental situation, including the non-involvement of the ward staff, was described to the subjects before admission. They were also informed that they would, from the time of their admission, be given the opportunity to engage in a productive task for which they would be paid in cash value tokens. They would be expected to support themselves on their earnings and would be able to save, in addition, a substantial sum of money that would serve as payment for their participation in the experiment. In effect, they were offered a job. A bonus of $150.00, later raised to $200.00, was also offered for completion of the study. Another inducement to the subjects to complete the experiment was specified in the contract each subject signed before joining the study. This was that, at the project director's discretion, tokens saved would be redeemed at only a quarter of their face value if the subject quit before the end of the allotted period.

Payment for production was calculated on the basis that a subject working steadily for seven and a half hours, five days a week should earn the equivalent of the net average wage in Toronto, less a quarter for rent. Heat, light, cleaning services and bed, but not clean bed linen, were provided free. All other goods and services were provided at actual street prices where these could be determined, or at a reasonable realistic cost.

Each unit of production was paid for as it was presented and passed as acceptable. The payment was made in the form of plastic tokens which were given a face value of $1.00, 25 cents, 10 cents or 5 cents. Each subject was given a different coloured set of tokens to facilitate data collection and keep track of inter-subject financial transactions. Goods were available from a small store which was stocked with cigarettes, liquor, beer, wine, candies, potato chips, toiletries, etc. All purchases were recorded. Payment for the various facilities available such as record player, table tennis, radio, and television was also recorded for each transaction and subject. Tokens could be saved and deposited in a "bank" to be cashed in at the end of the experiment for their face value.

Experimental design

The basic experimental design is decipted in Figure 1. From this figure it can be seen that the experiment lasted for 70 days with several distinct phases. For the first two weeks no cannabis was available; this is referred to as No cannabis phase 1. During the next week, unlimited cannabis was available on purchase; thus, this phase is called Free purchase phase 1. For the following 28 days a certain amount of daily cannabis smoking was mandatory for all subjects, but in addition more cannabis could be purchased should they so desire. The small arrows in the figure indicate

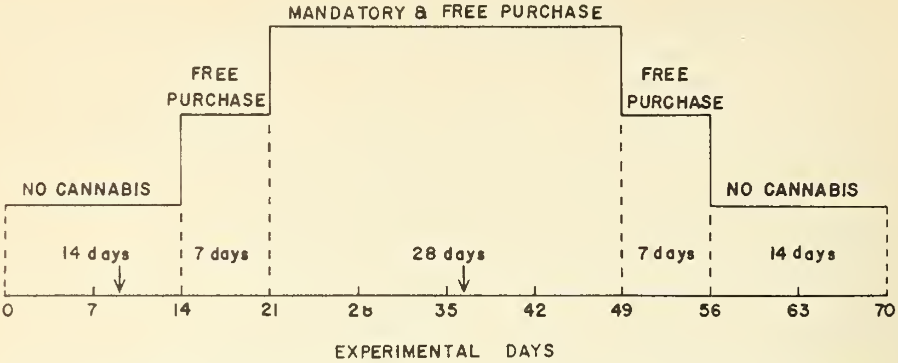

Fig. 1: The length of time, under each economic and drug administration regimen, is shown diagrammatically.

economic changes which are explained more fully below. It can be seen that one of these changes occurred during the mandatory plus free purchase smoking phase; we therefore refer to Mandatory plus free purchase phase 1 and Mandatory plus free purchase phase 2. After the mandatory phase the subjects were returned to the 7 days of free purchase conditions pertaining to Free purchase phase 1; thus it is referred to as Free purchase phase 2. By the same token, the final two-week period is referred to as No cannabis phase 2.

Payment

Payment per unit of production was $2.00 for the first 8 days, $2.25 for the next 28 days and $2.75 for the remainder of the study. These adjustments were not a part of the original experimental plan. The subjects made unanimous threats to leave the experiment if payment was not increased.

The production task

The work task chosen was the construction of small stools which measure 11½" in each direction. To produce the finished article the frame had to be assembled by banging the various wooden pieces together. A good friction fit without gluing was ensured by the fact that the hardwood was precision planed. Once the frame had been assembled the seat was woven with coarse sea grass.

The task was chosen by applying the following criteria:

(1) A good measure of skill could be quickly acquired.

(2) The product is easily judged with regard to quality.
(3) It demands attention but is not desperately tedious.
(4) The equipment required is not expensive.
(5) No potentially dangerous implements are required for the production process.
(6) A single unit could be completed within a relatively short time.
(7) The completed unit is attractive, functional and obviously saleable -- these were felt to be important factors in maintaining extra-economic motivation.

Preparation of cannabis cigarettes

Cannabis sativa 7B ex hybrid, supplied by the Health Protection Branch, Department of National Health and Welfare, Canada, was sorted to remove seeds and stems which constituted 16 percent of the total weight. This manicured dry plant material, assayed using gas chromatography, contained 0.95 per cent w/w Δ^9-tetrahydrocannabinol. The Δ^9-THC content of the material was re-assayed by our laboratory before and after the experiment and the results were in agreement with those provided by the Health Protection Branch Laboratory.

Preliminary tests indicated that this material had too rapid a combustion rate for efficient administration of the drug. Therefore it was stored over water until it reached a virtually constant weight (i.e. for a period of 5 days, with average water uptake being 11.4 per cent) before being made into cigarettes. Each cigarette contained 1.0 g of this moist plant material (i.e. the equivalent of 0.90 g dry material, containing 8.5 mg Δ^9-THC). Fresh cigarettes were prepared each week of the study, and these were stored over water until they were taken to the ward.

Drug assay of cannabis material

The following instrumental conditions were used in the gas chromatographic assay of the cannabis material: Varian Model 2100 gas chromatograph was equipped with Varian Model 20 recorder, flame ionization detector, and 6 ft. glass column 0.25 in. O.D. packed with OV-17 3 percent on Gas Chrom Q 100/120 mesh; gas flow rates for nitrogen, hydrogen and air were 59, 24, and 200 ml/min. respectively; injector, column and detector temperatures were 250, 235 and 275° C respectively.

The extraction procedure employed was based on modifications of the methods of TURK *et al.* (1969) and PATTERSON & STEVENS (1970). Duplicate 500 mg samples of dry, finely powdered, manicured material in 5 ml petroleum ether (b.p. 37 to 46° C) containing 5α-cholestane (internal standard) 1 μg/μl were vortexed in glass stoppered tubes for two 1-minute periods separated by 10 minutes. The material was centrifuged for 2 minutes, and triplicate 1 μl aliquots of the supernatant solution were injected directly.

A standard curve was prepared using reference standard $\triangle^9$-THC over the range 0.25 to 4.0 μg/μl with cholestane 0.5 μg/μl as internal standard. Peak height ratios plotted versus concentration ratios gave a linear curve over the concentration range employed.

Administration of the drug

The drug was always administered by smoking. A free purchase cigarette cost 50 cents. The mandatory dose was delivered in two 1 g cigarettes which were smoked one after the other with only a short time in between. The total smoking time was always less than an hour. Although smoking was to some extent self-paced, the subjects were urged to smoke as quickly as they could, to inhale and hold the smoke and not to leave long roaches. If this procedure was not followed the subjects were urged back into the prescribed pattern of smoking. During free purchase smoking the same procedure was followed except, of course, that the whole group was not necessarily involved on any one occasion. The mandatory dose was consumed at 7:30 p.m. in the TV lounge area of the ward. All subjects were required to attend and the smoking was supervised by two nurses.

The dose of $\triangle^9$-THC in each cigarette alone was thought to be sufficient to produce that level of intoxication which cannabis smokers describe as a "social high". This was assessed by several acute pilot experiments where all subjects reported being "nicely stoned" on a comparable dose which also reliably produced an elevated pulse rate and reddening of the eyes. These preliminary results tally with those of CAPPELL & KUCHAR (1973) whose subjects rated 1 g cigarettes 8.0 mg of $\triangle^9$-THC as 66 on a scale of potency ranging from 0 (not at all potent) to 100 (extremely potent). This information together with the findings of the *Canadian Cannabis Report* (1972) that the median social dose of $\triangle^9$-THC is approxi mately 6.0 mg, gives a high degree of confidence that 8.5 mg is a moderately intoxicating dose.

Urine collection

Urine samples of 50 to 100 ml volume were collected twice weekly upon the subject's wakening. They were immediately stored at -17° C.

Data collection procedures

A record was made every half hour of the dominant activity of each subject. A separate record was made of whom each subject was with, where he was and what drugs, if any, he was consuming.

Raters were instructed to check one activity only, and the ten categories were listed in order of priority, i.e. if a subject was engaged in two activities simultaneously, the one higher on the list was checked. (See Appendix A.)

Recreation included all active pastimes -- playing ping pong, cards or some unorganized impromptu game, engaging in writing, art work or making music.

Entertainment referred to a passive use of the entertainment facilities (TV, radio and record player) and reading. It was not checked when a subject was working, eating or recreating while listening.

Conversation was checked only when the subject was in interaction with another to the exclusion of all other higher priority activities.

Solitary signified that the subject was engaged in none of the higher priority activities but was out of bed and awake.

Resting Awake and Asleep were used when the subject was in or on his bed (or another horizontal surface) and was engaged in no other activity. The assessment of whether the subject was sleeping was at times difficult since an accurate judgment would involve waking the subject. If he gave obvious signs of being awake (eyes open or turned to see rater), resting awake was checked. Otherwise it was assumed that he was sleeping.

The remaining categories were literally interpreted and little used. Eating signified consumption of a main meal, Toilet and Personal Hygiene referred to all grooming behaviour and washing as well as use of a lavatory, and Other generally applied to times when the subject was in the store or off the ward for medical tests or outings.

The categorization In Group was independent of the activity rating and was intended to cover the situations in which a subject was pursuing some dominant activity other than conversation, but was nevertheless in a group with other subjects.

Raters were instructed to use the following cues available to them in a brief observation.

(1) Proximity. Was the subject close to another subject?

(2) Orientation. Was the subject's position one which facilitated interaction with another subject, e.g. eye contact possible without turning body, conversation easy?

(3) Conversation. Did the rater hear any conversation between the subjects?

(4) Sharing. Was the subject sharing either implements used for working or an entertainment facility (radio, record player) with another subject?

(5) Dominant activity. Was the subject engaged in an activity which was compatible with social contact, e.g. not writing or reading intently?

Using these cues raters were asked to assess whether the subjects involved had just been, were, or were about to be indulging in social interaction. It was felt that this was a necessary additional piece of information, since some major activities (e.g. working) clearly did not preclude social interaction (though they equally clearly did not necessitate it) and was meaningful in that subjects did in fact have a choice whether or not to be in the company of other subjects while doing other things.

Economic data

The time, item, service or facility purchased and the cost of each financial transaction was recorded. Subjects could spend only their own tokens; if they acquired tokens of a different colour (e.g. by gambling) they exchanged them for their own. This transaction was also recorded.

Subjects

Eleven male subjects volunteered for this experiment. Seven were considered suitable and accepted after a screening interview, but one withdrew before the experiment started. Prior to the screening interview the following criteria were used as prerequisites for inclusion in the experiment: single males, aged 20 to 35 years, with a history of regular cannabis use the previous year, and no history of heroin use, alcoholism, psychiatric treatment, attempted suicide, convictions for drug offences or crimes against persons or property.

The average age of the six accepted subjects was 24.33 years with a range of 21 to 26 years. Social class was assigned using HOLLINGSHEAD & REDLICH's criteria (1958). Subject 2 was in Social Class II, Subjects 1 and 3 Social Class III, Subjects 4 and 5 Social Class IV, and subject 6 was in Social Class V. All six accepted subjects were unemployed at the time of volunteering and all had an average monthly income of less than $200.00.

The parents of five of the subjects were alive; subject 6's parents had been killed in an automobile accident. In none of the subjects' parents was a history of psychiatric illness reported. The mother of one subject was considered as suffering from alcoholism. There was no history of psychiatric disorder, alcoholism or drug dependency in any of the subjects' siblings.

None of the subjects had a history of psychiatric illness, but subject 3 had consulted a psychiatrist following the end of a romance. None had made suicide attempts. Subject 6 was considered to be an excessive drinker. All six subjects had convictions for road traffic offences, but no other history of crime.

Subject 6 had been unemployed for the previous two years, while the remaining five had held between one and three jobs in the previous two years. The mean length of employment in the previous two years was 10 months, with a range of 0-18 months.

All six subjects were using cannabis, but no other drugs, at the time of assessment. The mean length of cannabis use was two years, with a range of 1-5 years. The mean frequency of cannabis use over the previous two months was more than once each week, with a range of use from once a month to daily use. All claimed to be moderate users of alcohol.

All six subjects had used amphetamines at some time during the previous two years. However, only subject 6 had used amphetamines intravenously. All six subjects claimed to have had passing experience with hallucinogens including LSD, mescaline and psilocybin. None had used heroin or other opiates. None of the subjects had experienced adverse reactions consequent on drug use, and none had reason to seek medical advice concerning drug use.

On clinical examination none of the six subjects was considered to show evidence of neurosis, psychosis or other form of mental illness. However, subject 6 was assessed as showing evidence of a personality disorder. This subject left the experiment after 43 days, giving as the reason that he could not stand being isolated from the mob of society, and that being unable to interact with staff was "inhuman".

During the experiment the subjects completed Raven's Advanced Progressive Matrices under supervision. Although there was no collusion among the subjects, in other respects the testing situation was not acceptable for accurate psychometric assessment. The subjects laughed and joked, and two failed to complete the test adequately. Individual results are therefore not presented. The group mean score (50.0) and the modal percentile rank (75-90) reveal that the group as a whole was above average in terms of this test. No individual's score fell below the 50th percentile.

The medical investigation

Every subject had his complete medical history taken and underwent a thorough physical examination on admission. Physical examinations were repeated twice a week during the study and on the day of discharge.

These examinations were done at a set hour of the day and were not temporally related to cannabis consumption.

Those subjects who had any medical complaints during the study period were allowed to make an appointment with the physician for an examination and/or treatment, apart from the regularly scheduled physical examinations. Subjects paid the equivalent of 55 cents in token for each visit (which was the proportion of the physician's fee not covered by the government medical insurance plan). They did not have to pay for medications, however, which were prescribed as a result of these visits. A set of "screening" tests was designed to indicate any physiological or biochemical abnormalities in main body functions which could arise as a result of drug effect.

Electroencephalograms, urinalysis and haemoglobin were recorded once a week; chest x-rays, white blood cell count, erythrocyte sedimentation rate, fasting blood sugar, blood urea nitrogen, SGOT, SGPT, cephalin flocculation and serum sodium, potassium and chloride determinations were made every two weeks throughout the subjects' stay. Baseline data were obtained on admission and on at least one more occasion before cannabis consumption began. At least two sets of measurements were taken after cannabis intake had ceased prior to the subjects' discharge.

Results

The following general format of data presentation will be followed. All relevant data is given in graph form which will depict the means for the group. On all graphs the significant experimental periods are indicated. When changes in the economic conditions occur they are denoted by arrows, and changes in the cannabis administration regimen are denoted by vertical dotted lines. The results of statistical analyses are presented in the text and the appropriate figure. The means for subject 6, who left the experiment on day 42 of the experiment, have been estimated where necessary using the method described by Kirk (1968, p. 146). When group means are compared, Tukey's Test for multiple comparisons of Honest Significant Differences (HSD) is used (Kirk, 1968, p. 88).

Although all graphs include group daily means from day 2 to day 69, all analyses of variance have excluded data from days 1 to 8. This exclusion process was decided upon because eight days was considered to be a reasonable settling-in period for staff and subjects, and, moreover, the first pay raise came into effect on day 9.

Cannabis consumption

The daily means for the group's consumption of cannabis in mg/kg are presented in Figure 2, panel *a*. During Free purchase phase 1 the highest daily mean consumption occurs on the first day and the last day is the lowest. On the first day of Mandatory plus free purchase phase 1, mean consumption was approximately double that of the previous day. It should be noted that this phase shows the three highest consumption days (days 26, 32, and 33). Mandatory plus free purchase phase 2 shows a smaller range of daily fluctuation than Mandatory plus free purchase phase 1, and appears to have settled at a somewhat lower level. On the first day of Free purchase phase 2, consumption fell to less than half the level of the previous day and stayed at approximately this level for 5 of the 7 days of this period.

An analysis of variance on the mean daily consumption level of each period was significant ($F=13.45$, $df=3/14$ $p < .01$). A comparison of the means for each period confirms the indication in Figure 2, panel *a* that

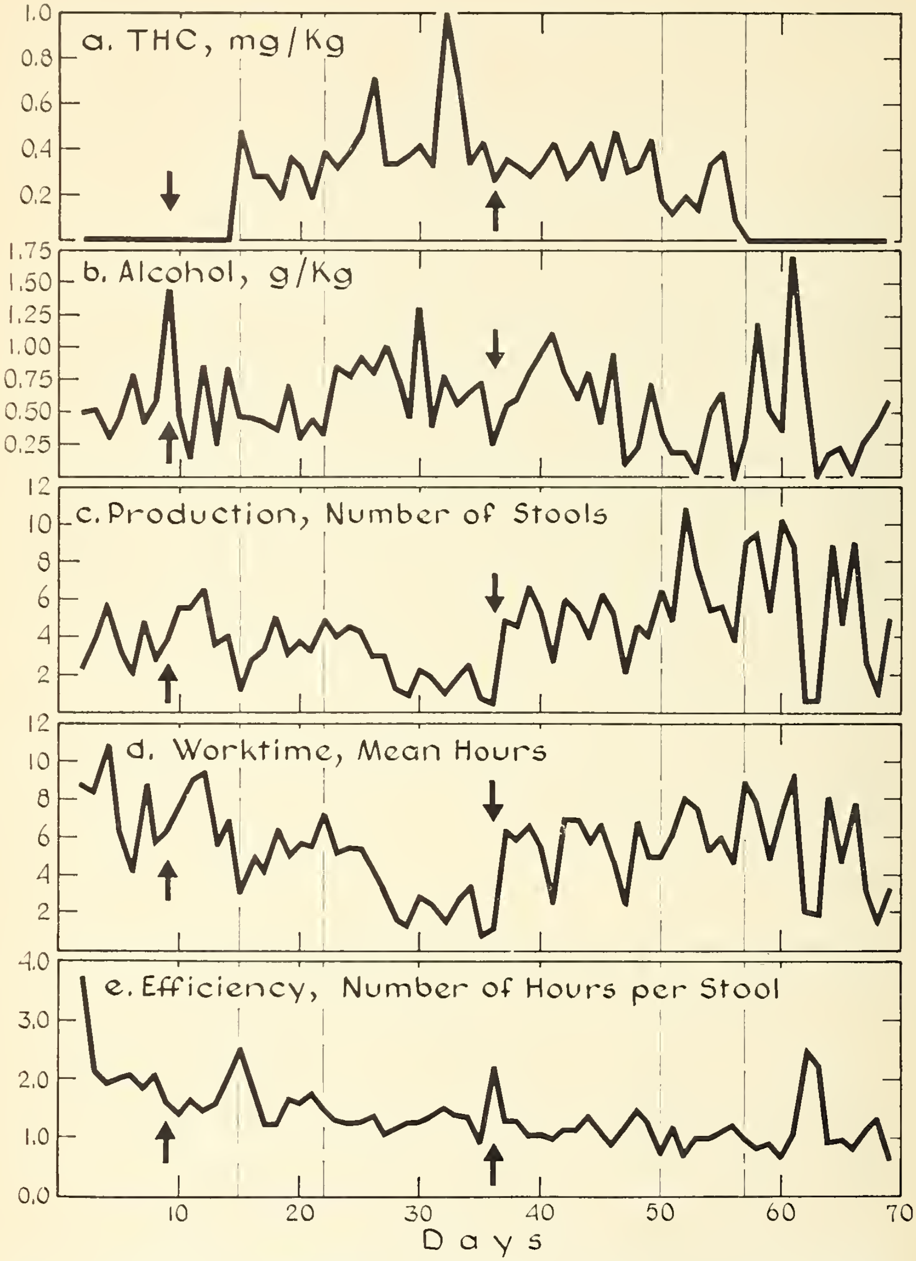

Fig. 2: Mean daily consumption for all subjects is shown for THC in mg/kg in panel a and mean daily alcohol consumption is given in g/kg in panel b. Panel c shows mean daily production of stools while panel d shows mean number of hours worked per day. Panel e indicates the mean number of hours per day taken to produce a single stool. The arrows indicate changes in rates of pay and the vertical dotted lines indicate the times when the drug administration regimen was changed.

the period of heaviest smoking occurred in Mandatory plus free purchase phase 1; the mean of 0.47 mg/kg was significantly higher than in any other period ($p < .05$) including Mandatory plus free purchase phase 2. Free purchase phase 2 also shows significantly lower mean consumption (0.20 mg/kg) than both the Mandatory plus free purchase phases (mean for Mandatory plus free purchase phase 2, 0.34 mg/kg). However, the mean for Free purchase phase 1 (0.30 mg/kg) differs only, as reported above, from the mean for Mandatory plus free purchase phase 1.

Alcohol consumption

The daily group mean alcohol consumption data are presented in g/kg in Figure 2, panel *b*. The most striking feature of these data is that the two days of heaviest drinking are during the two No cannabis phases. The day of heaviest alcohol consumption in No cannabis phase 1 occurred on the day when wages were first raised (day 9), and in No cannabis phase 2 on day 61. In general, the data show the two no cannabis phases to have the largest range of daily mean consumption, with the free purchase cannabis phases having the smallest. The mandatory phases can be interpolated somewhere between the no cannabis and free purchase phases with regard to range of daily variation in consumption levels. However, when the means for daily consumption for the significant experimental periods were subjected to an analysis of variance, no statistical differences were found ($F = 2.61$, $df = 5 / 23$, $p > .05$).

Relationship between alcohol and cannabis consumption

In order to get some idea of the degree of relationship existing between alcohol and cannabis consumption for individual subjects, correlation coefficients were calculated. Each subject's alcohol consumption in gm/kg for each day when cannabis was available was correlated using Pearson's *r*. For the five subjects, where complete data were available, the coefficients were significantly positive and ranged from .33 to .40.

Production

Daily means for number of stools produced by the subjects are presented in Figure 2, panel *c*. It can be seen that the learning of the task was quite rapid. A slight increase in production took place after the first pay raise. For example, on day 8, the day before the first pay raise, mean production was 2.83 stools. From days 9 to 14 overall mean production was 4.78. On day 15, when cannabis was first made available, mean production fell to 1.17, but over the next few days climbed to approximately its previous level. After a few days of Mandatory plus free purchase cannabis, a steady decline in productivity can be seen occurring up to and including day 36, when the second raise was granted. Day 37 shows a dramatic rise in productivity which is more or less maintained through Mandatory plus free purchase phase 2. It should be noted here that payment at the higher rate started later in the evening of day 36 and only a total of three units for the group was completed for inclusion in the data for that day. Free purchase phase 2 includes the most highly productive day. Production in No cannabis phase 2 was erratic, with a high daily mean of 10.20 and a low of 0.80.

The means of daily production for each of the experimental periods were subjected to an analysis of variance which proved to be statistically significant ($F = 9.13$, df 5/23, $p < .01$). Comparison among the means shows that a mean daily production of 2.57 during Mandatory plus free purchase phase 1 was significantly lower than means of 4.78, 6.26 and 5.72 for No cannabis phase 1, Free purchase phase 2 and No cannabis phase 2 respectively. During Free purchase phase 1, mean daily production of 3.14 was also significantly lower than the mean for Free purchase phase 2 and No cannabis phase 2.

The differences between mean daily production during Mandatory plus free purchase phase 1 (2.57) and Mandatory plus free purchase phase 2 (4.37) were not quite significant using this method of analysis and this was probably because Mandatory plus free purchase phase 2 included the day when the second raise was given later in the day on day 36. Since this comparison could be of special interest, at *t* test was run on the daily means comparing the two mandatory periods. This analysis shows the overall daily mean for Mandatory plus free purchase phase 1 to be significantly lower than for Mandatory plus free purchase phase 2 ($t = 3.20$, df = 26, $p < .005$).

Time spent working

The mean daily time spent working is presented in Figure 2, panel *d*. In general it can be seen that the shape of the work time curve tends to follow closely the shape of the production curve presented above in panel *c*. As expected, analysis of variance on the mean daily worktime for each experimental period was significant ($F = 9.94$, df 5/23, $p < .01$). Multiple comparisons among these means show the mean number of hours spent working during Mandatory plus free purchase phase 1 (3.31) was significantly lower than No cannabis phase 1 (7.43), No cannabis phase 2

(5.44), Free purchase phase 2 (6.11), and the mean for Mandatory plus free purchase phase 2 (5.19), which in turn was also significantly lower than that for No cannabis phase 1. The mean daily number of hours worked during Free purchase phase 1 (4.90) was significantly lower than those worked during No cannabis phase 1.

In panel *e* of Figure 2 an index of efficiency is plotted. This index simply shows the mean number of hours taken to produce a unit on each experimental day. The most striking aspect of this data is the steady overall decline throughout the experiment in the mean amount of time taken to produce a unit, thus showing a steady improvement in efficiency. The notable deviations occur on the first day of cannabis smoking (day 15), when the second raise was introduced (day 36), and days 62 and 63, which followed the day of heaviest drinking.

Spending

Mean daily spending in dollars is presenting in Figure 3, panel *a*. After the first raise these data show that the amount of spending tended to remain fairly stable with a few high points during the latter half of the experiment. The most notable of these was on day 40. The highest rate of overall mean daily spending took place during Mandatory plus free purchase phase 2 ($7.16) and the lowest was during No cannabis phase 2 ($5.10). An analysis of variance on the overall daily means for the significant experimental periods ($F = 4.25$, df 5/23, $p < .01$) and multiple comparisons showed mean daily spending during No cannabis phase 2 was significantly lower than during Mandatory plus free purchase phase 2. Mean spending during Mandatory plus free purchase phase 1 ($5.50) was also significantly lower than during Mandatory plus free purchase phase 2.

Savings

In contrast to the relatively stable rates shown in the spending data, the savings data presented as the mean difference between earning and spending in Figure 3, panel *b*, show marked trends and variations. The first raise does not seem to have had a substantial effect on the rate of saving.

The introduction of cannabis was accompanied by negative savings. This also occurred on two other days in this seven day period of free purchase. Savings remained positive for the first six days of Mandatory plus free purchase phase 1, but were negative thereafter until the second

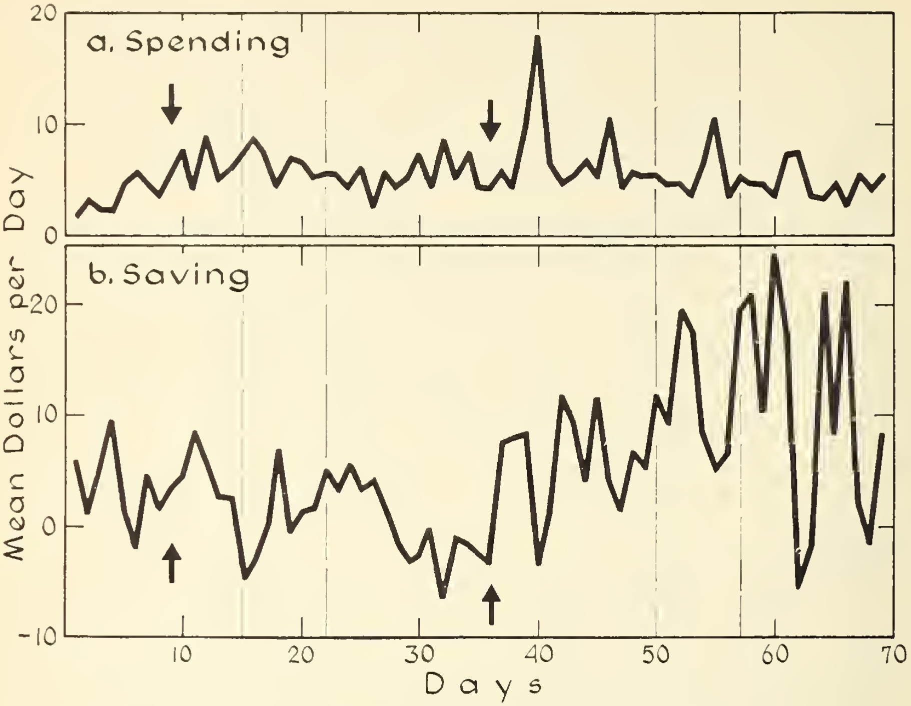

Fig. 3: Mean spending and saving in Canadian dollars is shown in panels a and b respectively. The arrows indicate changes in rates of pay while the vertical lines show times when the drug administration regimen was changed.

pay raise was introduced. During Mandatory plus free purchase phase 2, only on day 40 did mean spending exceed mean earnings. In general, savings seem to have settled at a somewhat higher level than during the previous two experimental phases. Free purchase phase 2 shows a generally higher level of savings than previous period. No cannabis phase 2 is characterized by relatively erratic behaviour, where high mean daily savings are interspersed with negative savings on several days.

Comparisons among the overall daily means for each of the significant experimental periods were indicated by a significant analysis of variance (F=11.3, df 5/23, $p < .01$). The mean daily savings during Free purchase phase 2 ($11.42) was significantly higher than the means for No cannabis phase 1 ($.57), Free purchase phase 1 ($0.41), Mandatory plus free purchase phase 1 ($0.28), and Mandatory plus free purchase phase 2 ($4.85), but did not differ from No cannabis phase 2 ($10.66). The mean for No cannabis phase 2, however, was significantly higher than both Mandatory plus free purchase phase 1 and Free purchase phase 1.

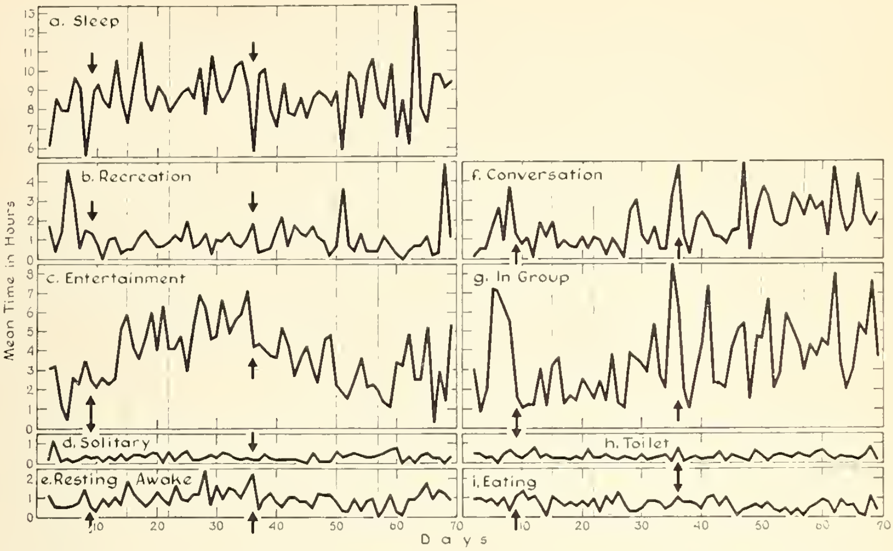

Fig. 4: All data in this figure refer to hours per day spent in various behaviours. Panel a refers to sleep, panel b recreation, panel c entertainment, panel d solitary, panel e resting awake, panel f conversation, panel g in group, panel h toilet and panel i eating. The arrows in each panel refer to wage changes and the vertical dotted lines refer to changes in the drug administration regimen.

Sleep

The mean daily time recorded for sleeping is presented in Figure 4, panel *a*. An analysis of variance on the means for the various experimental periods was not significant. Each period contained quite substantial daily variations, and no systematic trends were discernible.

Recreation

Mean daily number of hours spent in recreational activity is shown in Figure 4, panel *b*. Apart from days 5, 51, and 69, where the time spent in recreation is deviantly higher, there seem to be no systematic differences in the amount of time spent in this activity. This impression is confirmed by a non-significant analysis of variance on the daily means for the various experimental periods.

Entertainment

Mean daily hours spent in entertainment are presented in Figure 4, panel *c*. It is not difficult to summarize the picture presented in this figure. The amount of time spent in entertainment tended to increase up to the end of Mandatory plus free purchase phase 1 and to decrease thereafter, through Mandatory plus free purchase phase 2 and Free purchase phase 2. The trend is less apparent in No cannabis phase 2 because daily variation tends to be greater.

An analysis of variance on the overall daily means for the critical experimental periods was significant (F=17.32, df 5/23, $p < .01$). The impression gained from examining Figure 4, panel *c* is confirmed by the overall daily means of 2.87 hours (No cannabis phase 1), 4.93 hours (Free purchase phase 1), 5.27 hours (Mandatory plus free purchase phase 1), 3.87 hours (Mandatory plus free purchase phase 2), 2.22 hours (Free purchase phase 2), and 2.68 hours (No cannabis phase 2). Multiple comparisons among these means show that although the means for Free purchase phase 2 and No cannabis phase 2 do not differ statistically from each other, they are both significantly lower than the means for Free purchase phase 1 and Mandatory plus free purchase phase 1. The mean for Mandatory plus free purchase 2 was also significantly lower than that for Free purchase phase 2. The means for Free purchase phase 1 and Mandatory plus free purchase phase 1 are significantly higher than the mean for No cannabis phase 1. The mean for Mandatory plus free purchase phase 1 is significantly higher than that of Mandatory plus free purchase phase 2.

Solitary

An examination of Figure 4, panel *d* shows that on the average, very little time was spent alone and analysis of variance failed to reveal any significant differences between the overall daily means for the critical experimental periods.

Resting awake

Daily group mean hours spent resting awake are presented in Figure 4, panel *e*. Although the overall daily variation is small, there does seem to be a general tendency for more time to be spent resting awake (F=7.91, df 5/23 $p < .01$) during the first two periods of smoking than at other times. Multiple comparisons among the overall daily means for the six experimental periods show that the lowest number of hours spent resting awake was during Free purchase phase 2 (0.49 hrs) which was significantly lower than the means for Free purchase phase 1 (1.07 hrs), Mandatory plus free purchase phase 1 (1.25 hrs) and Mandatory plus free purchase phase 2 (0.93 hrs). The mean for Mandatory plus free purchase phase 1 was significantly higher than for both No cannabis phase 1 (0.68 hrs) and No cannabis phase 2 (0.72 hrs).

Conversation

The group daily means for the number of hours spent in conversation are presented in Figure 4, panel *f*. A slight suppression in mean daily conversation time during the first free purchase phase and the first few days of Mandatory plus free purchase phase 1 gives way to an overall upward trend. This trend is confirmed by an overall analysis of variance of the means for the significant experimental periods ($F = 66.37$, df 5/23, $p < .01$).

In group

Mean daily hours spent in group are presented in figure 4, panel *g*. Not surprisingly the shape of the in group curve is rather similar to that of the conversation curve, showing the same general upward trend as the experiment progresses over time. This trend is also supported by the results of an analysis of variance ($F = 65.89$, df 5/23, $p < .01$).

Toilet

The data for the mean daily hours spent in toilet activity are presented in Figure 4, panel *h*. The curve shows no systematic variation, which is confirmed by a nonsignificant analysis of variance. The grand mean daily time spent in toilet activities over the whole study was 0.34 hours.

Eating

Mean daily time spent eating is presented in Figure 4, panel *i*. The amount of time spent in eating daily suggests little systematic variation within a small range on this figure. However, an analysis of variance conducted on the overall daily means for the critical experimental periods proved to be significant ($F = 8.05$, df 5/23, $p < .01$). Multiple comparisons among these means revealed that the lowest mean during Free purchase phase 2 (0.44 hrs) was significantly different from those during No cannabis phase 1 (0.86 hrs), Free purchase phase 1 (0.75 hrs) and Mandatory plus free purchase phase 2 (0.71 hrs). Moreover, the No cannabis phase 1 mean was significantly higher than the mean for No cannabis phase 2 (0.55 hrs).

Discussion

One of the most important findings is that within its predetermined limits the "micro-economy" methodology devised for this study actually worked satisfactorily, although some difficulties were experienced (CONGREVE & MILES, 1974). The fear that the subjects would not stay in the situation under such constrained conditions was confirmed in only one out of the six subjects. It appeared that certain economic changes had to be made in order to maintain the experiment. However, with the benefit of hindsight and experience in subsequent and similar experiments, it appears that the experimenters could perhaps have won the games of bluff over the negotiated raises. In debriefing interviews, the subjects who stayed all reported that they almost certainly would not have left if the raises had been refused.

It was significant also from the methodological standpoint that the "non-involvement role" assigned to the nurses and attendants was not unduly resented by the subjects, nor was it impossible after appropriate training for the staff to adopt this role. This also had been a major area of concern. Nurses and attendants are traditionally trained to be involved with, and show concern for, the people under their care. Indeed some staff members did find it difficult to put on a front of neutrality towards subjects after a long training in treating patients. A small percentage of the staff at the end of the study declared themselves completely unfit for the role, and transferred to other areas. The vast majority, however, successfully adapted and stayed with the total project for about eighteen months, with a high degree of commitment which was reflected in remarkably low sickness and absenteeism rates, thus demonstrating that staff with medical treatment backgrounds can be engaged on research oriented projects of this nature with effectiveness and enthusiasm.

The work situation created for the subjects was found easy to handle in terms of recording and the actual production process. It cannot be said that the task was popular with the subjects, and complaints of boredom were frequent. However, the fact that five of the six subjects were sufficiently motivated to stay in the situation for ten weeks suggests that the task was not overwhelmingly monotonous, or as in many factory jobs, the economic rewards were sufficient to offset the tedium. It can be concluded therefore that the production aspects of the micro-economy constituted a successful device for retaining subjects and generating behaviour which could be used as a baseline, and in which changes can serve as measures of the effects of the drug.

The question now is whether the methodology, while logistically successful, proved to be sensitive enough to several drug effects. The "amotivational syndrome" was described by McGlothlin & West (1968) as a set of symptoms "including apathy, loss of effectiveness, reduced drive and ambition, diminished capacity or willingness to carry out complex long-term plans, to endure frustration, to follow routines or to successfully master new material" *(Canadian Cannabis Report,* p. 78). It was noted in the introduction that the amotivational syndrome has been used to describe chronic users. The subjects in this study had also been using the drug for some considerable time, and although a two week withdrawal period was instituted at the beginning of the experiment, it is doubtful that this short period of abstinence would start a reversionary process with respect to any behaviour patterns resulting from drug-induced personality change. The question for this experiment is whether some aspects of the syndrome can be elicited or emphasized by large daily doses of the drug. In some instances this does seem to be the case, in others not. An important implication of this syndrome which has often been suggested is a lack of concern for material rewards. Further data on this point are discussed later, but it is interesting to note that on two occasions the subjects took unanimous action in negotiating pay increases and price reductions. These were habitual cannabis users, but after only eight days in the study, they insisted that they had been misled about the amount of money they could make and save, and were being exploited.

The second round of nagotiations occurred in the mandatory dose period. The subjects complained that they could not earn at a satisfactory rate while being required to smoke so much cannabis. It is worth noting, however, that the mean amount of cannabis smoked over and above the required amount tended to be lower after the raise in pay. Consequently, if production had been a very important factor in the motivation of subjects, their pleas that they were inefficient because they were required to smoke so much have little logical validity. Savings and spending were, indeed, both low at this point. The decline had started, however, during a period of voluntary heavy drug consumption, Free purchase phase 1, in which heavy consumption was not only voluntary but also costly.

At the points where raises were negotiated, it seemed to the experimenters that the subjects might quit rather than continue at the lower rates of pay, or might resort to tactics of non-cooperation in, or active sabotage of, the experiment. It was therefore decided that to accept the confounding introduced by the changes was the lesser of two evils.

We have to consider three aspects of production: the amount produced (productivity), the time spent in production, and the ratio of productivity to time spent working (efficiency). In terms of productivity there seems little doubt that the introduction of the drug resulted in a fall. In Free purchase phase 1 productivity fell in all but one subject, and the overall mean went from 4.78 stools per day to 3.14 stools per day. Similarly, the overall daily mean of 2.57 for Mandatory plus free purchase phase 1 is lower than that for Free purchase phase 1, though not significantly. In Mandatory plus free purchase phase 2, there are indications that a reduction in cannabis consumption resulted in a rise in productivity. This trend continued into Free purchase phase 2, when cannabis consumption was again at its lowest. It should be recalled, however, that the difference between the overall mean production in Free purchase phase 2 and No cannabis phase 2 is not significant. Our conclusion then is that overall production is reduced by heavy daily consumption of cannabis and rises when the intake is reduced or eliminated. A more detailed analysis of the economic aspects of this problem is presented by MILES, BATTALIO, KAGEL & RHODES (1974). It is of note at this point that while there is a positive correlation between cannabis and alcohol consumption, alcohol alone cannot be the cause of these variations in production because there are no overall significant differences between mean daily consumption of alcohol for any of the significant experimental periods. This, however, should be qualified by pointing out the severe "hangover-related" depression of production on days 62 and 63 after an extremely heavy drinking bout on day 61.

Productivity considered alone is not the only significant measure in the context of the amotivational syndrome. As we have seen, the fall in productivity is matched by a fall in the amount of time spent working, not in efficiency, which in fact shows a steady slight upward trend. The mean time spent working fell from 7.43 hours in No cannabis phase 1 to 4.90 hours during Free purchase phase 1 and this decline continued into Mandatory plus free purchase phase 1, although the difference between the latter two means is not significant. However, the increase in time spent working in Mandatory plus free purchase phase 2, when cannabis consumption is significantly lower, raises the question again as to whether the cause of this increase is reduced cannabis consumption or the change in economic incentive. The answer is probably that both factors are involved However, it should be recalled that cannabis consumption is significantly reduced in Free purchase phase 2 and production and worktime are significantly higher during this same period while economic incentive remains constant. Thus the rate of cannabis intake is probably the most potent factor in affecting output. Without a control group, we cannot conclude that efficiency is not affected by cannabis consumption; it might have risen faster in the absence of the drug. We can conclude, however, that the fall in productivity is not due to a fall in efficiency. The subjects chose to spend less time working or, to put it positively, more time doing other things. It is important to know which activities were preferred.

WILLIAMS *et al.* (1946) reported an increase in mean daily sleep time over a 39 day drug administration period which returned to baseline during a 7 day withdrawal period. Our data do not confirm this finding. Differences in mean daily sleep time are not systematically related to high drug consumption and none of the differences between the daily means for the significant experimental periods approaches statistical significance. WILLIAMS' subjects possibly consumed much larger doses than those in the present study. In both experiments subjects rated the cannabis they were given as "good weed", and WILLIAMS' subjects smoked 9 to 26 cigarettes a day, with a mean of 17. The absence of quantitative assay on the cannabis used in WILLIAMS' study makes comparison difficult and we can only conclude that the doses used in the present study do not increase sleeping time.

It is more illuminating to examine the mean time spent daily in two of the activity categories which did show a significant association with high drug consumption. Subjects spent more time "resting awake" in Free purchase phase 1 and Mandatory plus free purchase phase 1 and 2 than they did during Free purchase phase 2, and more time in "entertainment" during Free purchase phase 1 and Mandatory plus free purchase phase 1 and 2 than in any other critical experimental period. It will be recalled that a subject was classed "resting awake" when lying down and engaged in no other activity. "Entertainment" was counted when the subject was watching television or listening to radio or record player, again with no other activity taking place. It is important to note that the increase in mean daily hours spent in "entertainment" during periods of high drug consumption does not mean that the subjects watched or listened more during these periods, but that they watched or listened more to the exclusion of all other activity.

We therefore tentatively conclude that in this study, an amotivational syndrome showed up in terms of decrease in the amount of time spent in productive work and a roughly corresponding increase in time spent being passively entertained and in resting in supine position doing nothing else. Apart from this evidence of lethargy we cannot confirm other presumed symptoms of the syndrome. We cannot conclude the efficiency with which the subjects worked was unaffected by the drug, but the effect, if any, was not large.

In relation to WILLIAMS' observation of "...general lassitude and indifference which resulted in carelessness in personal hygiene..." (WILLIAMS *et al.*, 1946 p. 20), we can say that the mean time spent in "toilet and personal hygiene" did not vary significantly over the critical experimental periods. There is some tendency for it to be lower in the high drug consumption periods, but the absolute range of the means (approximately 20-25 minutes) probably falls within the normal range for young men in Western culture. There was recorded in nurses' notes no systematic tendency for the subjects to become visibly (or olfactorily) less hygienic. At the dose levels administered in this study, there was no pronounced evidence of "social deterioration" such as that associated with "opiate addiction and chronic alcoholism" (WILLIAMS *et al.*, 1946, p. 20).

A more detailed analysis of economic behaviour will be published at a later date. However, it is interesting to note that overall spending remained fairly constant throughout the study, showing only a transitory rise after the increase in pay introduced in Mandatory plus free purchase phase 1 and 2. This is possibly due to subjects deferring expenditure until they knew the outcome of their negotiations. On the other hand, savings, calculated by the subtraction of daily spending from daily earning, showed a considerable fall on the introduction of the drug, though this did not reach an acceptable level of statistical significance, and then rose, once on the introduction of the increased incentive and again on the removal of the drug. Thus, savings ran at a moderate level in the "no drug, low incentive" period (No cannabis phase 1), fell drastically in both the "high drug, low incentive" periods (Free purchase phase 1 and Mandatory plus free purchase phase 1), regained a moderate level in a "high drug, high incentive" period, and rose to the highest level in the two "low drug, high incentive" periods (Free purchase phase 2 and No cannabis phase 2).

We have already argued that the subjects' insistence on negotiating higher pay does not imply a lack of concern for economic matters. We would also argue that the evidence shows that overcoming the inability or unwillingness to earn during the periods of high cannabis consumption is contributed to by a rise in economic incentive.

In terms of interpersonal social behaviour there seem to be no effects that can be attributed plausibly to the introduction or removal of the drug. The mean daily time spent in "conversation" shows a steady upward trend over the critical change-over time. Moreover, the time spent "in group" irrespective of the dominant activity also shows a marked upward trend over time. This may be interpreted as an effect of increasing familiarity between the subjects, or as the expression of an increasing need for social interaction in a restricted environment in which social interaction could only be between subjects, since the staff maintained a uniformly non-involved attitude.

It is also worth noting that, in common with both WILLIAMS *et al.*

(1946) and the *Mayor's Committee Report* (1944), we found no instances of aggressive behaviour and no overt sexual manifestations associated with the use of the drug. This finding is of some consequence since in both the studies cited above the subjects were prisoners who were in custodial care during the experiment. Thus, one would expect such constraints to minimize the likelihood of such occurrences. However, in the present study, with volunteer subjects under no such control conditions, the same observation pertains.

It is clear from the subjects' comments and nurses' observations that the dose levels employed (8.5 mg Δ^9-THC per cigarette and 17 mg mandatory dose) do indeed fall at the upper end of the range of doses in normal use. Thus, our aim of producing intoxication on a daily basis was almost certainly realized. The question of the delivered dose – probably about 50% of the THC in the cigarette according to Truitt's (1971) results and those of the *Canadian Cannabis Report* (1972, p. 133) and its comparability to orally taken doses cannot be resolved without the development of accurate techniques for measurement of drug *in vivo*.

It is not surprising that in the combined mandatory dose phases, where a minimum of 17 mg of THC had to be consumed, the highest mean daily consumption is shown. All except one subject consumed more per day during the mandatory phases than in Free purchase phase 1. During Free purchase phase 2, every subject consumed less than he did in each of the mandatory phases and less than he did in Free purchase phase 2. The initial heavy use of cannabis may possibly be attributed to the novelty of being allowed access to high quality "legal grass". During Free purchase phase 2 this novelty had probably fallen off. It is interesting that all subjects bought some extra cannabis during the mandatory smoking phases, but reduced their consumption markedly when the mandatory dose ceased.

The fact that, after five weeks of heavy cannabis consumption, all subjects voluntarily and substantially reduced their intake argues quite strongly that they were not dependent on the level of drug consumption they had been maintaining. Williams *et al.* (1946) made a similar observation about one of their subjects who voluntarily confined himself to one cigarette. It is also interesting that mean daily spending on cannabis during the mandatory phases fell from 61 cents to 21 cents after the increase in pay. This, it can be recalled, was a period when more income was available to the subjects, a lower absolute amount and percentage of it was spent on cannabis.

One speculative possibility is that the subjects were "tapering off" their dose to mitigate discomfort they anticipated when it was withdrawn altogether. Such behaviour has been reported in experimental studies of alcohol consumption by alcoholics (ALLMAN *et al.,* 1972 in press). There is, however, no support for this idea in the verbal reports of the subjects, who seemed almost relieved to be taken off a mandatory dose and expressed no concern at the removal of the drug from free purchase. It should be noted, however, that several bouts of heavy drinking occurred during No cannabis phase 2, and work performance during this period was somewhat erratic. This behaviour is difficult to interpret and could possibly be seen as being caused by abstinence from cannabis. It might equally have been the result of the excitement generated by the approaching end of the experiment.

A further possibility is that the subjects had developed "reverse tolerance". Without solid evidence of the existence of the phenomenon and with no account of the rate of its acquisition, loss and re-evocation, this possibility is hard to evaluate. It should be remembered, though, that these subjects were all experienced cannabis users, and underwent only two weeks of enforced abstinence. In fact, most subjects reported in debriefing interviews that the drug had appeared less potent as the experiment progressed. Nevertheless they voluntarily reduced their consumption, thus presenting the possibility of increased tolerance. It could also be argued that the recovery of production during the latter part of the mandatory dose period lends some support to the notion of developing tolerance.

The low but consistent positive correlation between the levels of cannabis and alcohol consumption over days is interesting. However, its main significance lies in the fact that the correlation is not strongly negative. Thus the substitution of the two drugs as intoxicants did not occur. The evidence here is consistent with the general notion that multiple concomitant drug use is a more likely characteristic of these subjects. Although the subjects were selected for having experience with both drugs such criterion need not have implied use of both drugs on a daily basis.

In the folklore of cannabis use there are conflicting reports of the effects of combined use of the drugs. The *Mayor's Report* (1944), for instance, quotes users as saying that beer will help reduce a cannabis "high" that has gotten out of hand, that whiskey consumed while smoking prevents the development of a "high" and that sweet wine consumed while smoking enhances and facilitates reaching a "high". There is evidence (MANNO *et al.,* 1970) that the effects of alcohol and cannabis on certain psychomotor and physiological functions are additive, but there is an absence of data on the simultaneous action of the drugs on subjective states and general levels of functioning in different environments and on patterns of parallel use when both drugs are available.

The situation is more confused when the levels of consumption are considered. The *Canadian Cannabis Report* (1972) states: "In general, survey studies of the incidence of drug use show that those individuals who use alcohol are much more likely than 'teetotalers' to use cannabis, and that most cannabis users still drink alcohol. In addition, heavy users of cannabis tend to drink more alcohol than light or infrequent users" (p. 126). The report states further that: "Many researchers have mistakenly assumed that survey data indicating a positive *between-subject* correlation of cannabis and alcohol use, at a single point in time, implies (sic) a positive relationship between the use of the two drugs within an individual over time" (p. 126). We have shown some supporting evidence of the latter type of correlation.

Turning now to the physiological and biochemical effects of cannabis, distinction has to be made between acute effects and chronic effects. Acute effects have been relatively easy to document and there is general agreement that from a clinical point of view, they are relatively few and minor: tachycardia (WEIL *et al.*, 1968; ISBELL, 1967), conjunctival injection (UNWIN, 1968; AMES, 1958), dry throat (ALLENTUCK & BOWMAN, 1942), and increased sense of hunger (CHOPRA & CHOPRA, 1957), have been found the most consistently reported reactions. A fairly complete compendium of other such effects is documented in the *Canadian Cannabis Report* (1972) although the literature continues to grow.

Data on chronic effects are much more difficult to obtain and evaluate. Most of those which have been reported are based on the observation of chronic cannabis users, but they are coloured by considerable "hearsay" evidence and are scientifically uncontrolled and inseparable from the possible effects of other drugs. Obviously experimental chronic administration of cannabis is barely feasible. It is therefore not surprising that just about every possible physical and psychological effect has been reported, in often conflicting ways, as summarized recently by SCHWARZ (1970).

In our subjects, essentially no major clinical changes were observed. There was no deterioration of general physical health, no significant weight changes occurred and all our subjects left the experiment in good physical condition. Of the five subjects who finished the experiment, four returned in six months for a follow-up examination. They were all in good physical condition, however shortly after the follow-up visit one subject became ill with hepatitis, presumably related to his parenteral drug use other than cannabis.

Reviewing specifically the various organ systems and the physiological and biochemical parameters that were measured, we concluded that in this limited "sub-chronic" experiment there were no appreciable effects noted on the cardiovascular system, nervous system (assessed by neurological examination), urinary tract, blood forming organs, liver function, blood sugar and serum electrolytes.

In one subject a transient episode of acute bronchitis developed (accompanied by radiological evidence of a plate-like atelectasis) at the early stage of cannabis consumption. Inhaled cannabis has been regarded as a respiratory irritant and both acute and chronic bronchitis (BOUGET, 1950; TYLDEN, 1967) have been described with its use. In our case however, this illness cleared up spontaneously in spite of continuing cannabis intake. Thus we have to regard this episode as a coincidental respiratory infection, not causally related to cannabis.

As to some of the electroencephalographic findings, it should be mentioned that the type of irregularity which was present throughout the study in one subject and which appeared intermittently in three other subjects -- i.e., diffuse low voltage theta activty -- is similar to what may be found in 10-20% of a normal control population and does not have any recognized clinical significance. It could be concluded that we did not see any clinically significant abnormalities in these EEG's which could be directly related to cannabis smoking. However, two major qualifications have to be made. First, these recordings were taken by strap-electrodes, which is not the best method. (In subsequent experiments needle electrodes were used, which permit more consistent and accurate placement.) Second, it should be emphasized that these records were given only a clinical type of interpretation. In our later experiments programme computer analysis of recordings is also contemplated. Thus, we can draw no firm conclusions from these pilot data alone.

Of course, there is a great deal of interest generated by cannabis as a drug potentially causing "brain damage", since its primary action seems to be on cerebral function. There have been reports on EEG abnormalities *(Marijuana and Health: A Report to Congress,* 1971) as well as on cerebral atrophy (CAMPBELL, 1971, p. 11) attributed to cannabis, but again these clinical reports were either uncontrolled or poorly controlled. Tetrahydrocannabinol given to experimental animals has been shown to produce EEG abnormalities (HOCKMAN *et al.,* 1971), but this does not permit extrapolation to human situations. At this point, we caution against jumping to conclusions as to the brain damage producing capacity of cannabis.

Both the negative and the few "positive" changes in this pilot experiment should be viewed with a great deal of reservation. This phase of our programme involved only a small group of subjects without placebo controls. The subsequent phases of our programme will consist of larger numbers of subjects as well as a placebo smoking control group which will permit more valid observations.

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Appendix A

The dominance hierarchy of activities, listed in decreasing priority, is shown in the same format as in the actual data collection forms used.

Working
Eating
Toilet (specify)
Recreation (specify)
Entertainment (specify)
Conversation
Solitary
Resting Awake
Asleep
Other (specify)

Place:
In group with:
Drug consumption:

Practical Difficulties in the Management of a Micro-Economy

G.R.S. Congreve[1] and C. G. Miles

INTRODUCTION

The micro-economy was developed by Miles and his colleagues (Miles *et al.*, 1974) as an experimental setting in which to assess the effects of sub-chronic[2] consumption of cannabis. It differs in, and by, design from other total environments, whether treatment or research oriented, but bears some resemblance to them. As in a mental hospital, our subjects were legally patients in an institution which took responsibility for and from them. As in a ship at sea, they were volunteers in a prolonged stay in a single sex community; and as in a prison the subjects were deprived of their freedom and depended totally on the staff of the institution for their privileges.

The micro-economy should be clearly distinguished from the token economy of Ayllon and Azrin (1968). Whereas the token economy is designed to establish certain behaviours in aberrant individuals to render them more viable in a social environment, the micro-economy was intended to be a social environment in which the individual's viability could be assessed. Where a token economy is engineered to provide reinforcers for a range of target behaviours, in our micro-economy only one response was reinforced; the token economy is designed to bring about directional change in behaviours, and the micro-economy is designed to permit a free range of behaviour.

The micro-economy was thus a relatively value-free organization, designed to simulate certain aspects of the natural economy. Our subjects were instructed in a production task (the manufacture of wooden stools with woven grass tops in the pilot study, the weaving of woollen sash belts in subsequent experiments) for which they received piece-work pay. Their food, and all goods and services, had to be purchased out of their earnings. Subjects could thus earn a lot or a little, and distribute their earnings among various goods, including savings, as they wished.

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[2] The term "sub-chronic" is taken from the LeDain Commission report on cannabis (1972) and refers to the regular (daily) use of the drug over a period of weeks or months rather than the years implied by the term "chronic".

In theory, the micro-economy could be adapted to simulate any feature of the natural economy – private ownership, inflation, unemployment, etc. – but in this series of experiments it was used as a standard situation in which to examine the effects of marijuana consumption on economic behaviour and various psychological and social variables.

By their nature, these experiments presented the experimenters with a complete set of problems – ethical, scientific, and practical. In this paper, we will discuss these problems and our solutions to them, and offer illustrative anecdotal material.

ETHICAL PROBLEMS

In our pilot study using the micro-economy as an experimental situation, we confined six volunteer subjects to a hospital ward for ten weeks. In each of our three subsequent studies we confined twenty volunteer subjects for fourteen weeks. In the micro-economy the subjects obtained *all* food, goods, and services through the staff of the institution: we delivered letters to them and took their replies to the mail. We required them to consume drugs to our schedules, and to submit to medical, psychological, and psychiatric examinations. They were denied contact with family and friends except by letter. They were all located every half hour of the day and night and their behaviour was assessed and charted. Their interactions with the staff of the institution were severely circumscribed.

In order to enjoy entertainment and recreation (even in order to eat) subjects had to produce goods by their labour, and submit these products for quality assessment by ward staff. Every economic transaction was recorded in detail, and every social transaction subjected to scrutiny and possible recording.

Ethically, it is necessary that an experimenter should obtain informed consent from subjects. Three factors seem to be involved – voluntariness, knowledge and competence. We went to some lengths to satisfy these requirements with thorough screening of applicants and full briefing, and are satisfied that our subjects were all competent to give consent. Nevertheless, these experiments, by virtue of their length and their extreme intrusion into the subjects' lives, raised a considerable number of ethical problems. In terms of ensuring our subjects' informed consent, we accepted only experienced marijuana smokers, and we described the experimental environment and conditions as fully as we could: we did, however, withhold some information, particularly regarding drug dosage, etc., and we withheld it until the end of the experiment. In terms of voluntariness, we clearly accepted only volunteer subjects into the experiment, but once they were in it we attached a heavy financial contingency to their continued consent. A subject who quit before the end of the experiment would forfeit the bonus payment and up to 75 per cent of earnings in goods or money. Thus if a subject found the drug dosage to be excessive or insufficient, or found our information on the conditions of the experiment to be inadequate, and wished to withdraw consent, freedom to do so was limited by financial constraints. This is not to say that our conditions were unethical. The problem was rather that we were continually aware that we were to some extent forcing our subjects to stay, and had to consider our behaviour carefully in this light. That is, when a subject's consent is fully informed and entirely voluntary, the experimenter carries no ethical burden. As voluntariness and knowledge decrease, the onus placed on the experimenter increases. In practice this meant that we had to adopt a flexible and informed approach to apparently small matters. In our first major study, we withdrew the drug from the ward because a majority of the subjects said they would rather quit than continue smoking marijuana. We were able to use this event in a scientifically productive way, but were certainly morally concerned over how far we could push the subjects at a stage of the experiment when they stood to lose many hundreds of dollars by quitting.

In each of the experiments at least one subject did insist on leaving. In one instance the subject forfeited about one thousand dollars, but in others very small sums of money were involved. The greatest pressure we felt able to use to restrain the subject from leaving (and causing our consequent large loss of data) was to suggest that he wait until the next day to make a final decision.

Another major ethical concern was that of the relationship between the ward staff and the subjects. The subjects were in an extremely vulnerable position vis-a-vis the staff. They were dependent for their earnings (through the quality control) and for the availability of their goods and services. We required the staff to maintain a 'non-involved' role with respect to the subjects. Essentially this entailed not initiating social interactions and responding to the subjects as neutrally as possible. The considerations here were scientific and strictly practical as well as ethical. Our concern was not, of course, simply that sexual relationships would develop between subjects and staff, but that liking or antipathy might be unfairly exploited, even unconsciously. Ethically, favouritism or victimization would be indefensible. From a scientific point of view, the mutual patterning of behaviour between subjects and staff could, even though the staff was systematically switched between the two wards in the latter studies, confound our findings with respect to the drug in a way that we could not subsequently untangle. Practically speaking, we were looking to the staff to record economic and social data with extreme accuracy and to maintain the physical security of the ward as well as withhold certain information with regard to the drug. In short we wanted the staff on our side, and could not risk a switch of allegiance.

SCIENTIFIC AND PRACTICAL PROBLEMS

The central problem in this series of experiments was in the balance between naturalism and control. To a large measure, the point of the experiments rested on our successful simulation of a 'natural' economy and society, while their value rested on the accuracy of the data collection and adequacy of control of drug consumption, considerations which lead to unnatural conditions. The generalizations possible from earlier sub-chronic studies (LaGuardia Report, 1944; Williams *et al.*, 1946) were limited by the fact that the subjects were prisoners and remained in prison, under prison discipline. It is not surprising, for example, that under such circumstances sexual and other violent assaults did not occur, nor did notably intoxicated comportment. Our aim was, using volunteers, to have conditions in which the subjects' behaviour would be much less constrained.

We adopted a more rigorous control of drug consumption in the latter experiments, requiring both mandatory and optional doses to be consumed under the supervision of staff, and measuring pulse rate before and after each dose. Control of the actual drug intake was clearly critical. We retained, throughout all studies, item by item recording of economic transactions and an 'activity check' made every half hour of the day and night. Ward staff recorded noteworthy events in a logbook; some groups of subjects became extremely interested in the contents.

Many features of the micro-economy were developed through anticipation or experience of difficulty in controlling the social and economic environment. For instance, we used tokens of different colour for each subject, to prevent stealing and to make it possible to trace borrowing and the fruits of gambling. We found it necessary to introduce a rule that subjects could use only their own tokens to make purchases; exchanges made between subjects were recorded on data collection sheets. The tokens had a cash face value, and were of the same size as normal circulating currency at nickel, dime, quarter, and dollar values, to emphasize the economic aspects of the subjects' activities: they were working for and spending real money.

We also anticipated difficulties with the production task and, as is pointed out later, to a large extent avoided them. In our pilot study, the subjects assembled and wove the seats for small wooden stools. This work was exceedingly tedious, the raw materials expensive, the finished product bulky and difficult to store. It was, however, potentially saleable, and therefore not totally meaningless as an earning activity, and easy to judge for quality of finish against objective criteria. In subsequent experiments the subjects wove sash belts on looms of a primitive variety. This task was more varied in terms of colour and design, while meeting other criteria more satisfactorily. In particular, the product could be finished in a relatively short period of time so that a subject who wanted to work only enough to pay for food and minimal incidental expenses would be able to do so. Subjects were paid $2.50 for each belt produced. This was calculated on the assumption that, at the mean rate of production, subjects could earn the average Toronto wage by working for thirty-five hours per week. In practice many subjects earned much more by being faster and working longer hours. Some subjects did, however, subsist by completing only one or two units per day.

Other problems anticipated concerned the ward staff. We expected to meet, and did meet, difficulties in persuading staff not to treat subjects as patients. In the other direction, we were concerned that the experiment as a whole might generate a dehumanized atmosphere in which the subjects would feel forced to rebel. As often as we had conflicts with staff over our 'cruelty' to the subjects, we had conflicts over 'letting them get away with it', that is, we were not, from time to time, sufficiently rigid, authoritarian, and punitive towards subjects to satisfy the staff.

A major problem was the maintenance of a physically secure ward area without the appearance of a prison and of adequate supervision of subjects' activities without a totally custodial atmosphere: we did not want to 'institutionalize' our subjects.

The parallel with a mental hospital is strong here, and much of what we did was guided by the findings of medical sociologists from Goffman (1961) on. We gave subjects free use of the courtyard at specified times every day, to play Frisbee or sunbathe. We provided supervised walks and use of the gym and sauna at small cost, and we arranged outings and movies at actual cost to them. In appearance, the ward areas were reasonably pleasant, modern and clean. Many subjects have reported, however, that they experienced considerable cultural shock on leaving the experiment and were, to that extent, institutionalized.

It is clear that ours was not an environment corresponding closely to the natural environment of most of our subjects. Nevertheless we believe that ours was a freer environment than has been used for similar experimentation in the past and that, for a variety of reasons, the apparently highly intrusive and seemingly somewhat ridiculous data collection procedures were not as salient to the subjects as they seem on paper. Subjects in general cooperated in data collection, and came to regard the procedures as a normal part of the set-up.

COMMUNICATION

As Watzlawick, Beavin and Jackson report (1967), an absence of communication among people who are in contact with each other is impossible. The act of refusing to discuss an issue conveys a message to the recipient which may vary according to the context and the recipient's predisposition, but it must convey a message. In this sense our initial concept of the 'non-involved' role for both experimenters and ward staff was inadequate. Our aim was to avoid the social reinforcement of any particular behaviours on the part of the subjects. We succeeded in also conveying to the subjects, to the acute distress of some and serious irritation of many, that they were individually insignificant and that the staff did not care what they did. There were, perhaps, two elements in this message, one that the subject was denied individuality, the other that he was not cared for, and the subjects felt, by their reports both during and after the experiments, both angry and anxious.

Over the course of the studies we became freer and more precise in our communication, and began to circumvent this problem. One move was to emphasize clearly to the subjects that our behaviour was to a large extent predetermined by the dictates of science, and that for scientific purposes their individuality was not significant. The subjects were thus forewarned and able to see the study as a joint venture in which we were as inhibited and mechanical as they were. The second element was a constant reiteration of our medical-legal responsibility for them as patients of the institution, and an increasing willingness on our part to listen to any subject who was upset and to make concessions in the rules to allow for individual distress. For example, we talked down a subject who became highly agitated on high doses of marijuana, we gave a subject leave to attend a family funeral, we arranged appointments at other hospitals for any physical ailments not treatable in the institution. We thus mitigated unwelcome messages, and in ways which did little violence to science and none to the truth of the situation.

With regard to the staff we adopted a democratic, power-sharing stance, on the lines of the therapeutic community approach of Maxwell Jones (1962) or the Administrative Therapy of Clark (1964). Before each experiment the entire staff met as a group to discuss and develop consistent procedures for handling actual and potential problems. During each experiment a logbook was kept on each ward to record not only significant interactions with and between subjects but also practical problems (with the food services for instance) or questions about procedures. The experimenters habitually answered these questions in the logbook and commented on the staff's account of events. The logbook was typed each day and copies circulated to both wards, so that each team was prepared for its return to the other ward on rotation, and all problems were shared between teams and all shifts.

We believe that this communication was a major element in our excellent staff morale. As with the subjects, we could point out to the staff that we were involved in a joint undertaking dictated in large measure by science and the logic of experimentation. We were also able to be seen as authoritative and competent in the area of scientific judgment and to demonstrate our involvement in a very concrete way by being on call throughout each experiment, twenty-four hours a day, seven days a week.

Another major factor in high morale was that the staff voluntarily chose to work on the studies. Many of our staff went so far as to drop their professional roles, and began to refer to themselves as research assistants as opposed to nurses.

These experiments involved many people. In addition to the twenty subjects, thirty-two ward staff, and two full-time experimenters, there were two other scientists associated with the study, one full- and one part-time research assistant doing concurrent tabulation and analysis, two secretaries and a part-time physician, psychiatrist, and social worker (the latter two for the first two studies only). All these people had regular access to the director and were convened in ad hoc groups as the occasion demanded. We emphasized the extreme importance of full information flow and the necessity of a large measure of power sharing and the blending of professional roles in an undertaking such as this.

CONTROL

Some authors (e.g., Haley, 1969) have argued that in any social system there is a definable element of control exercised by one group or individual over another: control, or being 'one-up', may shift from side to side, or may rest continuously with one party. One-upness is signalled by having the other party do one's bidding or by granting them permission to do their own thing: one-downness is signalled by losing a conflict. This process may be very subtle, with the pattern of control shifting constantly. In an institution or a large organization, the control in these terms may rest in the hands of persons with the least formal status. Haley has argued, for instance (1963), that the mental patient frequently maintains a very strong control over his therapist and his situation in hospital, though he appears to be at the bottom of the pile in a medical hierarchy.

We felt it to be essential that we retain control of both staff and subjects in this wider sense; not merely scientific control, but interpersonal control. Indeed, it was apparent to us that without the latter, our scientific control would be diminished.

We found in practice, whether or not this is essentially true in human nature, that the subjects had to exercise their autonomy or individuality. They felt in varying degrees a need to break the rules, to assert themselves in some area. They articulated this need very clearly in debriefing as something of a face-saving exercise, an individual statement in the face of a monolithic organization. Several of these gestures were not related to any other pressing need, though some were (one subject, for instance, wanted to telephone his girl friend and engineered the opportunity).

Two examples of this self-assertion illustrate the point. The wards had a keyed elevator system as part of the physical security system and one subject succeeded in stealing one of the keys. We could have demanded its return under some threat or let him keep it, and we decided on the latter course. We let him know that he would be fired if he left the ward, and he used his key only to call the elevator occasionally, not for any major breaches of security. We did not in fact determine which subject had the key until after the experiment. Another subject sat is his bedroom weaving most days. On one day he decided not to weave at all, but to be found holding his loom at each half-hourly check so that he would be assessed as weaving all day. Again, we did not know of this until after the experiment, but even if we had it is hard to see how we could have dealt with it. A rule that subjects must in fact be doing what they appeared to be doing would have been unenforceable and an invitation to disobedience.

There were then some occasions on which we let subjects make self-assertive gestures without entering into conflict with them, either by our choice or through ignorance. In a sense at least we avoided losing a conflict, and therefore control, by failing to fight.

CONFLICTS

Since communications with staff were generally good, conflicts and control issues between staff and experimenters arose relatively infrequently. The conflicts that arose were largely in areas we had foreseen. Staff sometimes became alarmed when required to behave in ways contrary to their professional training and experience. One staff member disliked serving alcohol to subjects, especially when the subjects were drunk. She had worked for some time in an alcohol de-tox centre. Staff became resentful and confused when required to follow absurd or impossible injunctions, as when, for instance, two staff were required to supervise an outing of eight subjects to a busy park area. These issues were resolved in three ways. Most frequently, discussion and renegotiation of the rules of the experiment resulted in staff feeling more comfortable with the situation. A number of staff discovered that they were unable to work on the experiment, and left for alternate placements in the hospital. In one instance, a staff member was encouraged to leave the staff, primarily because he was not controlled by the major factor controlling the rest of the staff and the experimenters, namely that they took a position of professional solidarity in the face of the subjects. He was a personal friend of some of the subjects, a situation we had attempted to avoid, and he clearly cooperated with the subjects in a variety of ways. It is interesting that his behaviour and attitudes were so easily detected by other staff. This may have been partly that his lifestyle was closer to the subjects than most staff (though not all: we had two ex-subjects on staff in later experiments) but was mainly that his involvement showed in ways ranging from his non-verbal communication to his extreme willingness to work with certain subjects or on certain duties (e.g., supervising outings).

A cardinal sin in the conduct of the experiment was to call a fellow staff member in question in front of the subjects. This solidarity was achieved partly by laying down precise procedures, discussed later, and partly by emphasizing the disastrous consequences of allowing conflicts among staff or between ward staff and experimenters to emerge. The subjects could exploit this sort of conflict to the detriment of the experiment and discomfort of the staff, and any hint that one staff member was "softer" on the rule than another led to immediate comment and confrontation. The staff were perhaps too aware, especially in earlier experiments, of the necessity of keeping control over the subjects, but this awareness itself helped keep them together as a team and led them to follow procedures and raise problems freely.

It was in control of the subjects that our main problems lay. As we have pointed out already, we were under pressure both scientifically and practically to maintain a high level of control, while ethically we could not push subjects too far.

It is a characteristic of total environments that, by the logic of control, any offence, however trivial, against control has the potential to become a major offence requiring ultimate sanction. For example, one of the authors as a schoolboy had had it explained to him that, while he would not be expelled from school for smoking, he most certainly could and would be expelled for disobedience. Disobedience would be inferred from his continuing to smoke, that is, refusing to recognize that he was controlled by the institution. A further refinement of offence against control is to submit to it while demonstrating one way or another that one has ceded control voluntarily. As Haley (1963) has pointed out, if one is in a position to give permission to someone else to control him, he retains a 'one-up' status and is in control. (This is the "surrender tactic", Haley, 1969.) Institutions have tried further sanctions. A soldier in the British Army who signalled, presumably semiotically, that he was not one-down could, until quite recently, be charged with "dumb insolence", despite rigid adherence to the letter of the law. Similarly, the patient, McMurphy, in Kesey's novel *One Flew Over the Cuckoo's Nest* (1962), who refused to be put down by electro-convulsive treatments, was ultimately lobotomized.

These are examples of the natural escalation of control measures applied by those formally in charge to those who will not adequately signal their 'one-down' status in any organization having control as an essential feature, and the micro-economy, as employed by us, was no exception.

In our situation, it was very much up to us to decide on which breaches of control we would take seriously and which we would ignore: we had no tradition of accepted practice to rely on, at least to start with. We also had to minimize the opportunities for the subjects to gain control in certain critical areas. The most important single rule in this respect was that the member of staff to whom the subject gave items of production for quality control would carry through the whole transaction. She or he would check the belts against the specified objective criteria, and make payments, and neither subject nor staff member could appeal decisions. After an inevitable learning period, during which staff were able to bring their standards closer and subjects learned to weave well, we had little trouble in this area. One subject, particularly angry with the controls of the situation, began to weave belts of amazing hideousness, and to weave them almost badly enough to be rejected. When he hit two failures in one batch, he improved quality, and soon became bored with the ugly design he had chosen.

This rule, part of the important staff solidarity, exemplifies our major control devices. We relied strongly on objective standards and rational (and hopefully reasonable) justifications, and we refrained from getting caught up in the "dumb insolence" kind of conflict. That is, the specifications for weaving were justified on the grounds that all subjects did a certain minimum amount of work on each unit. This last principle of fairness was applicable to many situations. We also decided, after the pilot experiment, to bring the marijuana consumption under more rigid control. In the pilot experiment, all subjects were on a mandatory dose for a period of four weeks, and could buy additional marijuana optionally for that period and a week extra at either end. While the consumption of the mandatory dose was supervised, we relied on the economic data, *i.e.*, purchase of marijuana, to reflect consumption in the optional consumption period. This was not satisfactory in the first main experiment, where half the subjects were on placebo, and we felt that we should have direct control of optional consumption. We thus started staff supervision of optional consumption, and later, pulse taking before, after, and fifteen minutes after consumption of the marijuana. Subjects all commented on the loss of realism or naturalism that resulted from these controls, and we had to balance carefully the gains and losses involved in instituting them. One result was certainly that we did keep ultimate control of marijuana consumption. Another was that we provoked some skilled counter-manoeuvres by the subjects. One subject in the placebo group stated the matter explicitly as a game. "The first duty of a captured officer in wartime is to escape and rejoin his unit, and the first duty of a dope smoker is to remain stoned." Some of these placebo subjects smuggled small, almost insignificant, amounts of marijuana into the ward, and obtained some from the group receiving the drug. The drug was passed by two subjects on the drug group as a "do as you would be done by" gesture, solidarity against the staff.

The illicit consumption of marijuana was detected and raised obvious problems, firstly of scientific importance, but also of legal significance. A feature of the experimental micro-economy was that our ultimate sanction against an individual – that of expelling him from the experiment – might not be particularly strong and anyway would constitute a serious loss of data. In terms of the power tactics, we felt we got a lot further by threatening to close the whole experiment, on the grounds that the events were illegal and anyway the study was becoming scientifically useless, than we would have by adopting the more common authoritarian tactic of punishing the offenders. In each group of subjects there were a few who recognized the necessity for control and accepted it, and also wanted very much to remain in the experiment. These subjects applied pressure to the "offenders" and, through intermediaries, an agreement was negotiated whereby the subjects surrendered their marijuana and listed their consumption by date and quantity, while the experiment moved into a cross-over phase in which the placebo group received mandatory and then optional marijuana in a test of tolerance. The subjects thus were put into a group pressure situation, with clear objective justification and an apparent bargaining gain, while we regained control of the drug consumption and obtained some retrospective data which, though unreliable, was better than none.

We dealt similarly with another situation in which we suspected a subject of having taken amphetamine. In this case, which occurred in the last experiment, urine tests confirmed the presence of amphetamines. We applied very strong pressure to the subjects as a group and to the individual, but could find no explanation for the behaviour. We did not in the end expel the subject, and accepted the findings as an unexplained mystery. We obtained from the subjects, however, all drug materials, under threat of closing the experiment, and made it perfectly clear that the taking of drugs was (a) likely to be detected and (b) could lead to the closure of the experiment. We also made it clear that a full account of the drug taking would be accepted and the subject would not have to leave the experiment. What the intervention achieved was the messages noted above, and the continued participation of the subject, who, if she had indeed knowingly taken drugs, was not about to do so again.

While some of the time it was advantageous to us to throw problems to the subjects as a group, in the pilot experiment we did lose control in one important area: that of payment to the subjects. On two occasions the subjects presented us with ultimatums stating that they required more money for their participation. The critical points in their argument were that they had been led to believe that they would make more than they were making and that some of the medical investigations, particularly EEG done with needle electrodes, were painful. They asked for special payments for EEG tests and a weekly wage for participation. We felt that less violence was done to the experimental design by increasing the payment per unit of production. It transpired in debriefing that they would not have quit the experiment, though they might have started a campaign of disruption, if they had not received an increase. The crucial element in our giving raises was our uncertainty as to whether they had been led to expect more payment. Hence our emphasis in later experiments on thorough briefing. In all the remaining experiments, particularly the first main study, subjects claimed that they could not earn enough to make their participation worthwhile. We were able to refer to the briefing and to precedent, and had little argument over payment.

It was, surprisingly, on minor matters, that we came closest to firing subjects, an instance of the escalation logic referred to earlier. In major incidents and crises it was easier to appeal to the subjects' reasonableness, and to exploit the internal pressures of the group and to show how science had us, as well as them, at its mercy. Over small matters, the control issue emerged more clearly. Two examples illustrate this. One subject wanted to see an experimenter to arbitrate a dispute with staff. Since it was 2:00 a.m., the staff would not call the experimenter. The subject then found a way to jam his bedroom door so that the staff could not conduct their half-hourly checks. The staff called the experimenter who came to the ward, unjammed the door, and refused to discuss the original issue between staff and subject. On reflection this situation probably was a marginal win for the staff-experimenter axis, since although the subject got the experimenter to the ward, he only did so by shifting the ground of the dispute to the half-hourly checks – from smoking to disobedience as it were – where the experimenters had to intervene to maintain an important principle.

In another instance a subject persisted in using an Allen key to open his window. This disrupted the air conditioning of the whole wing of the hospital. After repeated re-lockings of the window and requests that they not be opened, an experimenter was called to the ward again, just before the mandatory consumption of marijuana. The subject refused to undertake not to open the windows. The experimenter told staff to remove the subject's marijuana and call the physician for a pre-discharge physical. After a tense two minutes, the subject undertook not to open windows. This incident was significant for its clear control message. After the experiment finished, a "reasonable" subject told us that, had we lost that confrontation, the disrupters in the group would have extended their activities and the subjects who wished to remain in the experiment would have lost their power to influence the whole group.

We do not suggest that the description of the micro-economy in terms of its implicit control struggle or communication needs is complete. It is clear that subjects experienced very considerable stress, pleasure, change in attitudes and behaviour in many directions. It is also certain that many things happened which we do not and never will know of or understand. This is an incomplete account by any standard. Nevertheless, these are the terms in which we understood the problems at the time, and if we have abstracted any general principle of running an experimental micro-economy it is that a long-term experiment with human subjects is a political venture (interpersonal politics) in that it concerns broad issues of freedom and autonomy and that the art of conducting such an environment is very much the art of the possible.

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The Effects of Cannabis and Negotiated Wage Rate Changes on Income and Job Performance in an Experimental Token Economy

C. G. Miles,[1] R. C. Battalio, J. H. Kagel and G. F. Rhodes

INTRODUCTION

Most studies of the effects of cannabis smoking have been either experimental studies of acute effects, epidemiological surveys or clinical reports. While each approach contributes in its own way to the growth of our knowledge of the drug and its effects, we remain ignorant of the long term effects of regular cannabis consumption, uncomplicated by other drugs, on individual economic behaviour. A better understanding of these effects can be achieved through long term experimental studies in functioning economic systems. In this paper we report the results of one such study.

The experiment discussed was the pilot study of a recently completed series of experiments conducted by the Addiction Research Foundation of Ontario, Canada (LeDain Commission, 1972, Annex B). A token economic system was set up in which volunteer subjects agreed to live and work continuously for 70 days. The structure of the experimental economy closely approximated the structure of a national economic system. Subjects were completely dependent on earnings from a job task to support themselves; they could purchase a wide variety of consumer goods which were made available consistent with the need for confinement during the study, or could save for future consumption. The experimental sequence with respect to cannabis availability followed an ABCBA design with a baseline (A phase) of no cannabis, a B phase in which unlimited amounts of cannabis cigarettes were available for purchase, and a C phase in which each subject consumed two

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mandatory cannabis cigarettes per day, while additional cannabis cigarettes were available for purchase. Midway through the C phase, an unscheduled change in experimental conditions occurred when the subjects successfully negotiated a 22% increase in wage rates.

The primary focus of the present report is on the effects of cannabis availability and subject-negotiated wage rate changes on income and production in the economy, and on the relationship between the wage rate changes and changes in cannabis consumption. In addition to the substantive conclusions reached with respect to the effect of cannabis and wage rates on income and job performance, the present study illustrates the technological feasibility of using planned environments with volunteer subjects as laboratories for the experimental and analysis of individual economic behaviour.

STRUCTURE OF THE ECONOMY

The experimental economy was housed on the third floor of an annex to a large hospital. The unit had independent kitchen, housekeeping and security services. Token earning behaviour consisted of assembling precision-planed stools and weaving seagrass tops for them. No institutional limit was placed on the number of stools that subjects could produce. Each completed stool was paid for, initially, at a rate equivalent to $2.00 Canadian currency. Subjects had unlimited access to work materials and each subject was free to select his own daily work schedule.

Each subject received a bed, heat, lights, and cleaning services free of charge. A store was operated in the annex where standard cigarettes, soft drinks, candy, alcoholic beverages, toiletries, etc., could be purchased. Meals could be purchased from the hospital cafeteria, snack bar, or from take-out restaurants. Subjects could regularly purchase retail items from outside the hospital through a purchasing agent. Prices of goods and services purchased by the subjects were generally matched to prices in the Toronto area.

A bank was provided where subjects could store their unspent tokens. No interest was paid on these deposits. Unspent tokens were convertible to Canadian currency at the termination of the experiment with no loss in value.

Subjects remained residents of the economy continuously for the duration of the experiment. A $200 bonus was paid to all subjects completing the study, while withdrawal from the study prior to completion was penalized by forfeiture of three-quarters of all unspent tokens. The structure of the economy is described in detail in the first paper in this volume (Miles, *et al.*, 1974).

Measurement of Economic Variables

The record of individual stool production is the number of stools constructed by a subject and accepted by the attendants who inspected the stools for quality. Income within a period is measured as the number of acceptable stools produced during the period, multiplied by the piece rate in effect during the period, plus any gratis payments received during the period. Gratis payments consisted of a small sum of money given to subjects at the start of the experiment to support themselves until they were familiar with the job task, plus payment for occasional medical and psychological examinations.

The record of individual subject spending is taken from daily purchase sheets on which the staff recorded the item, price, and time of the purchase. Each day the tokens collected as payment for purchases were counted and balanced against the purchase-sheet totals. Where unreconciled discrepancies arose, the purchase-sheet record was accepted as the more accurate record.

The measure of time spent working was recorded by the staff at regular half-hour intervals throughout the day. The staff raters were instructed to check only one activity from the following hierarchy: working, eating, toilet and personal hygiene, recreation, entertainment, conversation, solitary, resting awake, asleep, and other. If a subject was simultaneously engaged in more than one activity, only the highest in the list was checked, e.g., if a subject was conversing and working, only working was checked.

Cannabis intake is measured as the number of cannabis cigarettes, containing 8.5 mg Δ^9–THC, smoked by each subject. This record was maintained independently of the record of cannabis purchases and, to the extent subjects bought cigarettes for each other, the two records will not match.

METHOD OF STUDY

The subjects in the pilot study were 5 single male volunteers.[2] The average age of the subjects was 24 years, with a range of 21 to 26 years. All were unemployed at the time of volunteering; average monthly income was less than $200. All subjects were using cannabis at the time they volunterred; mean length of cannabis use was 2 years. All subjects were screened in an attempt to eliminate hard drug users and those with a history of psychiatric treatment and alcoholism.

Both the scheduled changes in cannabis availability and the unscheduled changes in rates of pay involved changes in experimental conditions. Table I shows the sequence of the changes. Under free purchase conditions, cannabis was available at all times in unlimited amounts of 8.5 mg Δ^9–THC cigarettes which sold for .50¢ each. Under mandatory smoking conditions, all subjects were required to smoke consecutively two 8.5 mg Δ^9–THC cigarettes each evening at 7:30 p.m., with only a short time between cigarettes. During the mandatory smoking conditions, subjects could purchase additional cannabis cigarettes under the same conditions as during the free purchase period. The first increase in wage rates occurred on day 9 of the study when the rate was increased from $2.00 to $2.25 per stool. The second wage rate increase occurred in the middle of the mandatory smoking period and resulted in an increase to $2.75 per stool. The subjects' major bargaining weapon in both cases was a unanimous threat to leave the experiment if wage rates were not increased.

In the analysis which follows we exclude the first eight days and the last seven days of the study. The first eight days are excluded due to the difficulty of separating the effects of the wage rate change on income and production from the effects

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[2] Six subjects originally enrolled in the experiment. Subject No. 6 voluntarily left the study on Day 42. Data for this subject are omitted from the analysis.

TABLE I

EXPERIMENTAL CONDITIONS

Days of Experiment	Cannabis Availability	Wage Rate per Stool
1 – 8	No cannabis	\$2.00
9 – 14	No cannabis	\$2.25
15 – 21	Free purchase	\$2.25
22 – 35	Mandatory smoking	\$2.25
36 – 49	Mandatory smoking	\$2.75
50 – 56	Free purchase	\$2.75
57 – 70	No cannabis	\$2.75

of learning and mastering the job task. The last seven days are excluded because in this study, as well as in the subsequent experiments, the last two or three days of confinement are typically characterized by large, uniform decreases in subject output which appear to be related to the immediacy of reentering society rather than to cannabis availability or to wage rate changes.

Overview of Economic Behaviour

In Figure 1, aggregate per capita income and spending by experimental weeks is shown with a 45° line through the origin which contains the locus of points where income equals consumption.[3] The level of aggregate spending (see Figure 1) did not increase very much with increases in the level of subject income, and during most weeks income exceeded consumption, resulting in positive net saving flows. Aggregate per capita consumption exceeded income only during the second week of the first mandatory smoking period; this will be discussed later. Income exceeds consumption for all other weeks due to the full convertibility of unspent tokens into Canadian currency at the end of the experiment (Battalio, Kagel, Winkler, *et al.*, this volume). It is evident that the structure of wages and prices in the economy readily facilitated a standard of living substantially exceeding subsistence levels and allowed for large accumulations of individual savings by the end of the experiment.

EXPERIMENTAL RESULTS

Figure 2 shows the average daily per capita income by weeks under the various experimental conditions. The data clearly indicate that under like conditions of cannabis availability the higher wage rate was associated with higher earned income levels. This result, as well as the other behaviours commented on below, holds uniformly across individual subjects (see Appendix Tables). The increase in income levels was so large that, in most weeks following the wage increase, individual

[3] We have excluded Days 1-9 and 64-70. This means that the first no cannabis period consists of a 6-day week. Sunday is the day of the week which is missing. Examination of the data shows no Sunday holiday behaviour with respect to production so that these data are comparable to the other periods reported.

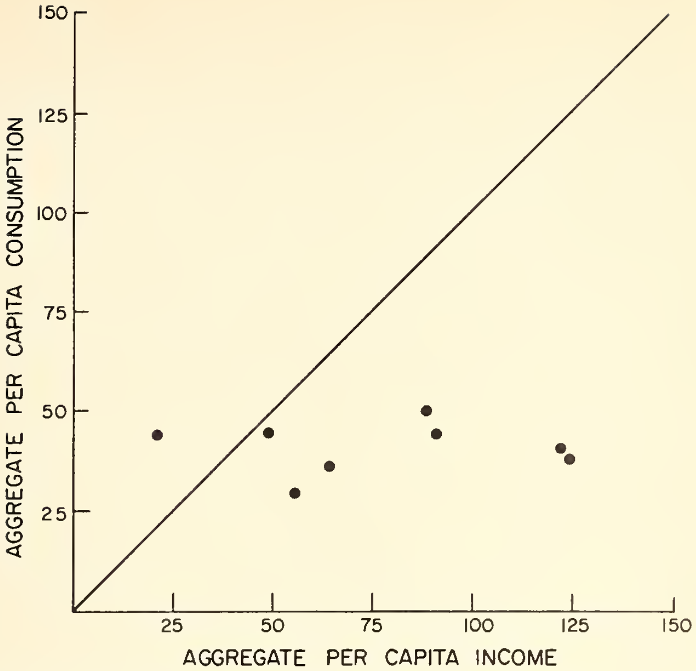

Figure 1 *Weekly income and consumption data*

subject's income levels exceeded the highest level the subjects had attained prior to the increase in wages, irrespective of conditions of cannabis availability. We note, with respect to the unusually low level of income reported for the second week of the first mandatory smoking period, that for the last several days of this week the subjects were effectively on strike while they bargained for the second wage increase.[4] Excluding the observations for this week does not alter the conclusions reached above.

As shown in Figure 3, the increases in income following the wage raise were accompanied by increases in stool production under all like conditions of cannabis availability. The observed increases in stool production are not predictable on the basis of past token economy research. While much evidence exists in token economy literature that increases in real wage rates significantly affect work performance, the amount of work performed often decreases rather than increases with a rise in real wage rates (see for example, Battalio, Kagel and Winkler, this volume).[5] The 22% increase in wages negotiated by the subjects would have resulted in increases in income levels, the avowed purpose of the pay raise, even if production levels had remained constant or even substantially declined between periods. Further, while any comparisons between the experimental economy and national economic systems must be qualified by noting that important differences in institutional structures exist between these systems, it is of some interest to note that the historical record for the United States and other industrialized countries in the twentieth century shows increasing real wage rates per hour with corresponding decreases in hours worked. During this period it was not uncommon for union negotiators to bargain

[4] The nurses' log notes chronicle this. See especially the entries for Subject 2, beginning with Day 39.

[5] In these studies, the income level either increased or remained constant while the upper income earners simultaneously did less work.

for both increased wages and decreased numbers of hours worked.

Examination of the data in Figure 3 also shows that the periods of mandatory cannabis consumption, under either wage rate, were associated with comparatively lower stool production under the same wage rate, when cannabis was not available.

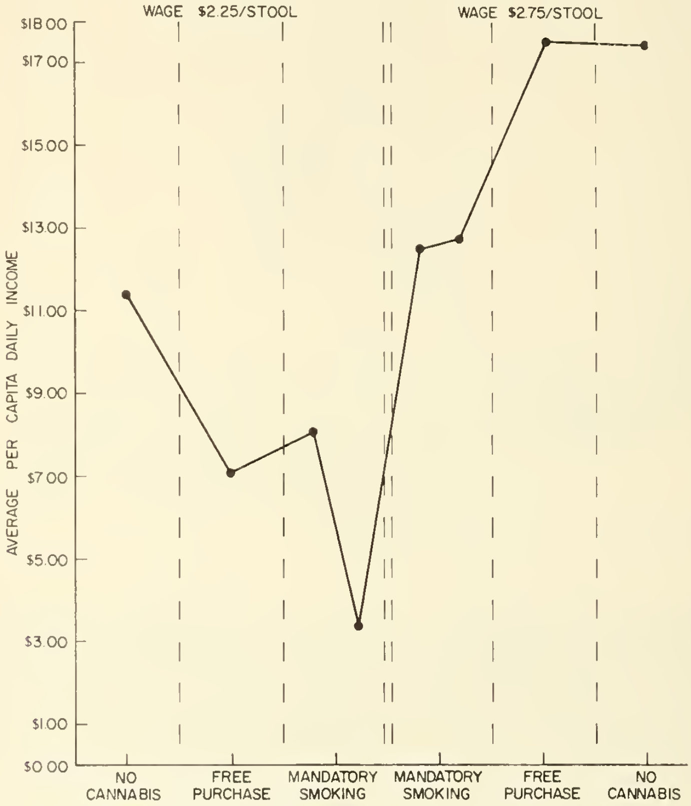

Figure 2 *Average daily per capita income*

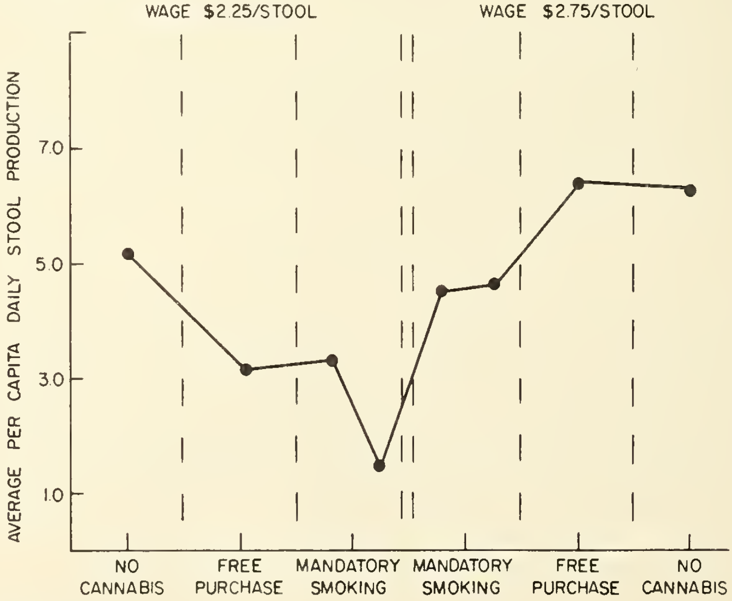

Figure 3 *Production*

However, when cannabis intake was completely in the subjects' control (free purchase periods), stool production was substantially lower under the low wage rate than when no cannabis was available; under the high wage rate production levels were approximately the same as when no cannabis was available.

A probable cause for the marked difference in stool production between the two free purchase periods and the two mandatory periods appears to have been the magnitude of cannabis actually consumed. These data are shown in Figure 4. The number of cannabis cigarettes smoked was substantially lower in the second free purchase period with the higher wage rate than in the first free purchase period. Further, cannabis consumption was also lower in the second mandatory smoking period, during which production levels were higher, than in the first mandatory smoking period. Since in both mandatory periods each subject smoked two cannabis cigarettes per day, the reported difference is in the number of additional cannabis cigarettes purchased. Thus, the data in Tables A-3 and A-4 indicate that under identical conditions of cannabis availability, higher wage rates were associated with higher production levels and lower levels of cannabis consumption.

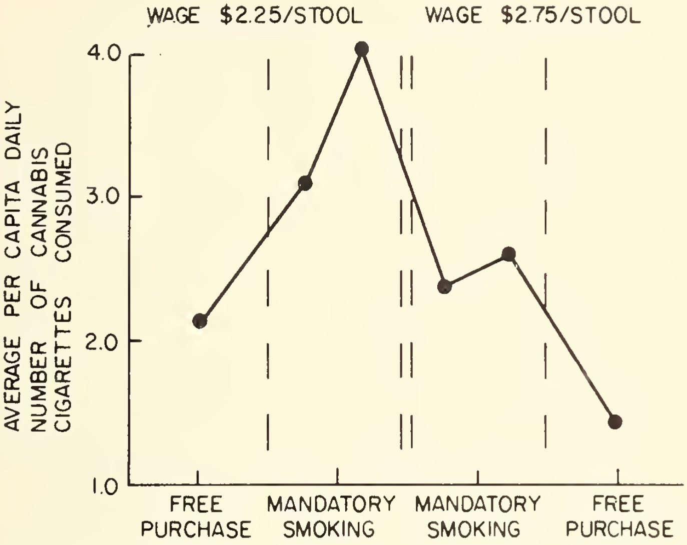

Figure 4 *Cannabis consumption*

Changes in production can be characterized by changes in the number of hours worked and in the efficiency or speed with which the work is performed. Equation 1 defines this relationship, where P is the production of stools, H is the hours worked, and E is the number of stools produced divided by the number of hours worked.

$$(1) \qquad P = E \cdot H$$

Figure 5 presents the average per capita daily hours worked and efficiency data by weeks for the experimental periods. The data show that under the low wage rate, the decreases in production associated with the introduction of cannabis were the result of fewer hours worked, while efficiency remained the same or increased. The jump in production associated with the increase in wage rates under mandatory and free purchase conditions was the result of both increased hours worked and more efficient production. However, the higher production under the second, as compared to the first no cannabis period resulted only from improved efficiency while hours worked were uniformly and substantially lower. Thus, the changes in production reported in Table A-3 resulted from changes in both efficiency and hours worked.

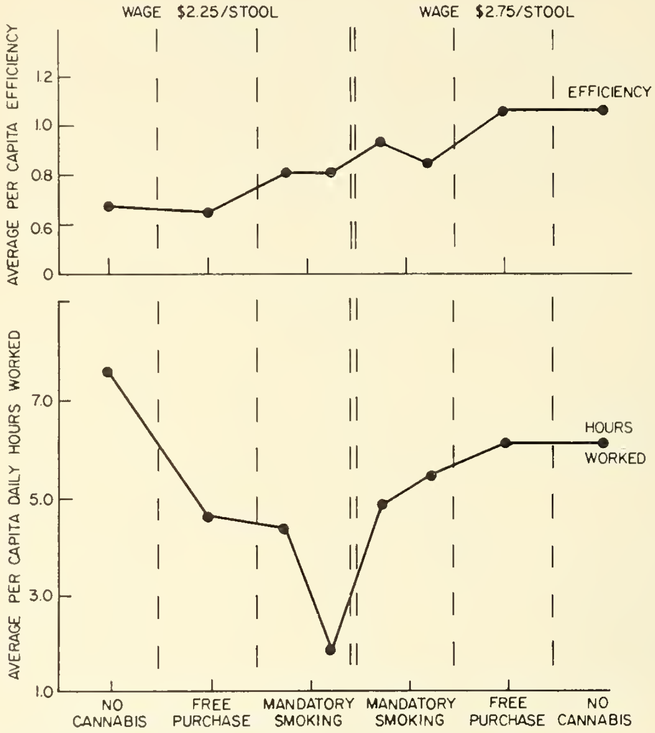

Figure 5 *Efficiency and hours worked*

DISCUSSION

One clear implication of our analysis is that under conditions of cannabis availability, behaviour can be modified by changes in economic contingencies. With an increase in wage rates, income and production increased under like conditions of cannabis availability, while the level of cannabis use declined. The inverse relationship observed between income and production levels and cannabis use are explained below in terms of the time intensive nature of cannabis as a consumption good relative to the production task.

The after effects of the consumption of the commodity, cannabis, are of relatively long duration. Depending on the dose levels, major psychological effects usually last several hours, while milder effects may endure for a half day or longer (LeDain Commission, 1972, p. 34). Direct evidence that these after effects interfered with the job task of the present study is contained in the experimenters' reports. During the mandatory smoking phases of the experiment, when subjects were required to smoke two cannabis cigarettes at 7:30 p.m., marked changes were exhibited in their work habits with a reduction of evening and night work activity and an increase in daytime work activity.[6] This interference which smoking cannabis had on the work task may have been due to either diminished job task efficiency and/or a relative enhancement of the enjoyment of nonwork activities following cannabis use. In either case, worktime activities were reallocated away from post-cannabis periods.

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[6] These observations will be subject to more systematic analysis upon the completion of the processing of the activity data in a form where activity sequences *vis-à-vis* cannabis consumption can be examined.

This reallocation of worktime does not necessarily imply that cannabis use *per se* will result in decreased production and income levels. Since worktime did not exceed an average of 60 hours per week for any individual, some levels of cannabis use may have resulted in a substitution of cannabis-related activities for other leisure time activities. However, as with other time intensive consumption goods, such as golf, fishing, watching television, etc., beyond certain use levels their consumption will interfere with production. Such use levels were apparently attained in the first free purchase period and under both mandatory smoke periods, when cannabis use for 4 of the 5 subjects exceeded the levels attained under free purchase conditions. However, since hours worked and efficiency between the second free purchase and no cannabis periods showed little change, cannabis use during the second free purchase period had been reduced to a level such that cannabis-related activities competed with other leisure time activities rather than production.

This interdependence of production and cannabis use may partially explain the sharp drop in production reported between the first no cannabis period and the first free purchase period. As the subjects were aware of the nature of the experiment for which they had volunterred, it may be assumed that cannabis, which would be available at some time during the experiment, was a commodity of strong preference to them. As a result, during the first no cannabis period the subjects may have exhibited unusually high levels of production in anticipation of using the income built up to finance consumption of large quantities of cannabis when it became available, while working minimal amounts (see Battalio, Kagel, and Winkler *et al.*, this volume). Whether consciously planned or not, subjects 1 and 5, who exhibited the sharpest decline in production during the first free purchase period, behaved this way. Their consumption substantially exceeded income during the free purchase period, a result which could not have been achieved without the associated high production levels and saving during the preceding no cannabis condition. This sequence, inherent in the experimental design, appears to have spent itself by the first week of the mandatory smoking period. Dissaving had virtually stopped by this time and the two subjects most clearly affected increased their production levels above those of the preceding free purchase period.

In interpreting the effects of the wage rate changes on production and cannabis consumption, two additional factors merit discussion. First, the wage rate changes were subject-negotiated and were preceded by several days during which the subjects were effectively on strike. Consequently, part of the increased production and income reported may have resulted from the subjects' attempting to make up for the income lost during the strike week prior to the wage increase. While this interpretation does not alter the principal conclusion that both production and cannabis consumption were under the control of economic variables, it does suggest that an experimenter-induced wage rate change of equal magnitude may have had a different impact than the one reported. Second, our analysis has only explored responses over a limited range of the wage rate variable. There is strong evidence that the response to wage rate changes depended upon the subjects' baseline income level as well as the magnitude of the change in the wage rate variable (Battalio, Kagel, Winkler, *et al.*, 1973). At higher initial income levels or with a large wage rate increase, subjects may have responded with decreased production levels while income increased or remained constant. Determination of the response of individual workers' output to changing wage rates is strictly a matter for empirical research (see Fleisher, 1970).

The effects of cannabis and wage rate increases on efficiency and hours worked remain inconclusive at present. No systematic pattern of changes in efficiency or changes in hours worked was found to explain the changes in the production data. This could result, in part, from the institutional structure of the experimental economy, where hours worked and efficiency were totally flexible and strictly under the subjects' control. Under this institutional setting, hours worked and efficiency may be interrelated, e.g., working longer hours may stimulate finding short-cuts to speed production, which in turn decreases the need for working longer hours, while consistently working faster may only be possible by, or stimulated by, working fewer hours. Under these circumstances questions regarding the effects of cannabis on efficiency and hours worked can be more profitably studied in the main experiments where there were no wage changes, experimental conditions were maintained for substantially longer periods of time, and control groups were available for comparison.

SUMMARY

The results of our analysis show that increases in both income and production levels resulted, under all like conditions of cannabis availability, in the subject-negotiated wage rate increases. The increased production levels were accompanied by decreased levels of cannabis consumption. The implication drawn from these observations is that both production and income levels, as well as the level of cannabis consumption, are determined, in part, by the economic contingencies of the environment.

ACKNOWLEDGEMENTS

This paper is a revision of an earlier draft presented at the International Symposia on Alcohol and Drug Research at the Alcoholism and Drug Addiction Research Foundation, Toronto, Canada, October 1973. The authors acknowledge receipt of useful criticisms from the participants. The research was partly supported by N.S.F. Grant GS 32057, "Interpretation Systems for Empirical Theories of Consumer and Factor Demand," (Principle Investigators: R. L. Basmann, R. C. Battalio, and J. H. Kagel), and the Alcoholism and Drug Addiction Research Foundation of Ontario, Project E206 (Principle Investigator: C. G. Miles).

APPENDIX A

TABLE A-1

AVERAGE DAILY INCOME, CANADIAN DOLLARS*

	Wage $2.25/stool				Wage $2.75/stool			
Subject	No Cannabis	Free Purchase	Mandatory Smoking		Mandatory Smoking		Free Purchase	No Cannabis
1	13.12	3.54	11.89	3.21	19.25	14.93	24.75	22.39
2	12.75	9.00	6.75	2.89	11.79	15.32	20.04	20.43
3	10.50	10.61	6.75	2.25	7.86	8.64	14.54	12.57
4	12.00	9.00	10.61	6.43	16.11	19.25	20.04	25.54
5	8.62	2.89	4.18	1.93	7.46	5.50	8.25	6.29
Average	11.40	7.01	8.04	3.34	12.49	12.73	17.52	17.44

*In this and subsequent tables individual subject averages may not sum to the average for all subjects due to rounding the individual averages.

TABLE A-2

AVERAGE DAILY SPENDING, CANADIAN DOLLARS

	Wage $2.25/stool				Wage $2.75/stool			
Subject	No Cannabis	Free Purchase	Mandatory Smoking		Mandatory Smoking		Free Purchase	No Cannabis
1	6.67	8.68	4.70	6.02	6.44	6.29	5.75	4.66
2	4.19	4.81	3.46	6.62	7.98	4.39	4.91	4.53
3	6.12	5.28	4.74	7.39	8.15	6.01	4.36	6.81
4	5.94	7.70	4.70	6.56	9.04	7.74	7.75	5.91
5	6.74	5.31	4.89	5.31	4.69	6.69	5.07	4.36
Average	5.93	6.36	4.50	6.38	7.26	6.22	5.57	5.26

TABLE A-3

AVERAGE DAILY STOOL PRODUCTION

	Wage $2.25/stool				Wage $2.75/stool			
Subject	No Cannabis	Free Purchase	Mandatory Smoking		Mandatory Smoking		Free Purchase	No Cannabis
1	5.8	1.6	5.3	1.4	7.0	5.4	9.0	8.1
2	5.7	4.0	3.0	1.3	4.3	5.6	7.3	7.4
3	4.7	4.7	3.0	1.0	2.9	3.1	5.3	4.6
4	5.3	4.0	4.7	2.9	5.9	7.0	7.3	9.3
5	3.8	1.3	1.9	.9	2.7	2.0	3.0	2.3
Average	5.1	3.1	3.6	1.5	4.5	4.6	6.4	6.3

TABLE A-4

AVERAGE DAILY HOURS WORKED

	Wage $2.25/stool				Wage $2.75/stool			
Subject	No Cannabis	Free Purchase	Mandatory Smoking		Mandatory Smoking		Free Purchase	No Cannabis
1	7.7	2.9	5.9	1.7	6.6	6.6	7.8	6.9
2	8.4	5.9	3.4	1.6	4.1	5.7	6.8	7.0
3	8.4	7.5	4.4	1.5	4.5	5.5	5.4	6.0
4	7.2	5.0	5.9	2.9	5.9	7.0	6.5	7.4
5	5.9	2.3	2.6	1.2	3.3	2.4	3.6	2.5
Average	7.5	4.7	4.4	1.8	4.9	5.4	6.0	6.0

TABLE A-5

EFFICIENCY: AVERAGE DAILY STOOL PRODUCTION DIVIDED BY AVERAGE DAILY HOURS WORKED

	Wage $2.25/stool				Wage $2.75/stool			
Subject	No Cannabis	Free Purchase	Mandatory Smoking		Mandatory Smoking		Free Purchase	No Cannabis
1	.76	.55	.90	.83	1.06	.83	1.16	1.17
2	.67	.68	.89	.82	1.03	.97	1.07	1.06
3	.55	.63	.69	.67	.63	.57	.99	.76
4	.74	.80	.80	.98	.99	1.00	1.12	1.26
5	.65	.56	.70	.71	.83	.85	.82	.91
Average	.67	.64	.80	.80	.90	.84	1.03	1.03

TABLE A-6

AVERAGE DAILY 8.5 MG CANNABIS CIGARETTES SMOKED

	Wage $2.25/stool			Wage $2.75/stool		
Subject	Free Purchase	Mandatory Smoking		Mandatory Smoking		Free Purchase
1	3.93	3.86	4.29	2.00	4.00	3.43
2	1.64	2.71	3.14	2.57	2.14	1.29
3	.93	2.29	3.71	2.57	2.14	.71
4	1.71	2.86	4.29	2.00	2.43	.29
5	2.07	3.86	4.71	2.57	2.71	1.57
Average	2.06	3.11	4.03	2.34	2.69	1.46

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Income, Consumption and Saving in Controlled Environments: Further Economic Analysis

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INTRODUCTION

During the last few years researchers in token economic systems have become increasingly concerned with economic aspects of behaviour in these systems (Winkler, 1971, 1972, 1973a; Osborne, *et al.*, 1972; Miles *et al.*, 1972). Much of this research has been directed towards investigating the relationship between income, consumption and saving behaviour. While these same behavioural relationships have also been of primary interest to economists investigating behaviour in national economic systems, the research efforts in the two disciplines have proceeded independently, with little, if any, interface. Cooperative research between experimental economists and behavioural psychologists in planned environments promises to speed the growth of understanding of economic behaviour in these systems and to facilitate the development of the relationships suggested by the initial investigations (Kagel and Winkler, 1972)[2]. This paper represents such a cooperative effort devoted to a re-examination of the relationship between income, consumption and saving behaviour in token systems.

In the first section of the paper we present the formal concepts, definitions and relationships used by economists to describe and analyze income, consumption and saving behaviour in national economic systems. An understanding of the economist's use of these concepts and relations is essential to transferring the concepts to token economy research. Using the concepts and relationships developed, we compare and contrast income, consumption and saving behaviour between a therapeutic token system, a token system using volunteer subjects and the United States economy. Differences in the institutional-environmental structures of the different economic systems are shown to lead to important differences in the behaviour observed. Conclusions reached in earlier studies of saving behaviour in token systems are re-evaluated in terms of the economic concepts developed and the implications of the re-evaluation for planning more optimal therapeutic environments in behaviour modification programmes are discussed.

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[2] The Kagel and Winkler paper is primarily devoted to discussing the benefits for economists of cooperative research in token economic systems (also see Kagel, 1973). An example of such a cooperative research effort directed at a question primarily of importance to economists is found in Battalio, Kagel, Winkler, *et al.* (1973).

ECONOMIC CONCEPTS OF INCOME, CONSUMPTION AND SAVING

Definitions

In economic theory the consumption schedule is defined as the relationship between income and total expenditures[3]. Both income and total expenditures, or consumption, are flow variables. That is, they are measured over a period of time, say a week, a month, a year or whatever time period is most suitable given the question at hand. Saving as a flow variable (hereafter referred to simply as *saving*) is defined as the difference between income and consumption over a period of time. Saving as a flow variable corresponds to what Winkler (1972) has called the economic balance of a token system. Since saving is defined as income minus consumption, once we know an individual's or group's consumption schedule we can derive the relationship between income and saving which is called the saving schedule. Further, given the savings schedule we can, of course, derive the consumption schedule working through the definition that consumption plus saving equals income.

Saving as a stock variable (hereafter referred to as the *stock of saving*) is defined as the accumulated past saving flows measured at a point in time; e.g., at the end or the beginning of the time period over which a flow of saving is measured. The stock of saving corresponds to the variable that Winkler (1972) has called saving. Just as saving may be positive, zero or negative over any period of time, the stock of saving may be positive, zero or negative at a point in time, the latter case only occurring in economic systems where borrowing is permitted.

The relationship between changes in the stock of saving, saving flows and the consumption schedule are all definitional. For the stock of saving to increase (decrease) between two points in time, the saving flow must be positive (negative) over the period between those two points in time. Similarly if the stock of saving is to be the same at two points in time, the flow of saving must be zero between the two points. A zero saving flow over a period of time implies that income equals expenditure over this period and the average propensity to consume, defined as the ratio of total consumption to total income, is equal to 1.0. Similarly a positive (negative) saving flow over a period of time implies income is greater (less) than consumption over this period and the average propensity to consume is less (greater) than 1.0. The relationships defined above correct a stock-flow error in the use of these concepts in Winkler (1972, p. 4) where a constant critical stock of saving (CRS) is specified while being at a point on the consumption schedule where the average propensity to consume is less than 1.0 which results in a positive net saving flow.

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[3] More precisely the consumption schedule (also called the consumption function) is a *mathematical representation* of the relation between aggregate income and consumption used to *predict* aggregate consumption from aggregate income data. Such functions are obtained using statistical estimation procedures which typically show income to be an important determinant of consumption in the national economy.

Saving in United States Economy

In a mixed capitalist economic system such as the United States, economists have directed attention to four basic institutional-environmental factors promoting individuals and families to accumulate and hold stocks of saving: 1) to acquire certain consumer durable commodities which are expensive relative to normal income flows such as refrigerators, washing machines, automobiles; 2) to provide an equity fund necessary to establish and maintain a business; 3) to provide for certain future expenditures such as a funeral and retirement, an estate for surviving spouse, children and other dependents, anticipated expenditures of substantial size relative to current income such as children's education and a reserve for undesignated contingencies, that is, "a rainy day"; 4) in the absence of all other factors, to bridge the gap between receipts of income and outflows of expenditures which typically do not coincide within the time dimensions used to measure income and consumption.

Within this institutional-environmental framework, economists have identified several empirical relations between income, consumption and saving. The benchmark empirical study of this kind is Goldsmith's (1955) two volume study which examines both the cross-sectional and over time relationships between income, consumption and personal saving behaviour. The cross-sectional relationship between income and personal saving flows, *i.e.*, the relationship, across income classes, between average income and average net saving for a given year, shows that in recent years the 10 percent of the households with the highest income have positive average net saving flows which account for most of the positive saving in the economy for that year; while households with the lowest incomes have negative net saving flows (dissaving) (Goldsmith, 1955, Vol. I, p. 9 and Table Z-24, p. 258). Comparison of the relationship between net worth (which corresponds to stocks of saving in the token economy[4]) across income groups for any given year shows positive net worth to be concentrated at the higher income levels but the degree of concentration to be less than that of positive net saving flows for the year; e.g., the ten per cent of households with the highest income in 1949 accounted for almost all personal net saving for that year but for only approximately two fifths total net worth of all households for that year (Goldsmith, 1955, Vol. I, p. 9). Time series data, *i.e.*, annual estimates of income, consumption and saving for the whole economy, show that the average ratio of personal saving to income for "normal" (non-war) periods from 1897 to 1949 was approximately +11% (Goldsmith, 1955, Vol. I, p. 6). That is the average propensity to consume for the entire time period was about .89. Further, the personal saving ratio has exhibited marked cyclical fluctuations, rising sharply during periods of prosperity and falling steeply during depressions (Goldsmith, 1955, Vol. I, p. 7). These continued, sustained, positive aggregate net saving flows have partially been channelled by financial institutions to the business sector of the economy and are the necessary counterpart to the positive net investment flows and continued growth of capital stock experienced by the economy over this period.

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[4] Net worth is defined as assets minus liabilities. Token economies typically do not allow for borrowing and do not have inheritances. Consequently, in token economic systems net worth is non-negative and equals saving stocks as we have defined them here.

Extensions to Token Economies

Differences in the structures of national economic systems result in differences in the institutional-environmental framework promoting the accumulation and holding of saving stocks. These differences can, in turn, be shown to result in differences in saving behaviour (see, for example, Furubotn and Pejovich, 1973). In extending the economist's concepts of income, consumption and saving to token economic systems we must recognize that there are important differences in institutional-environmental factors controlling saving behaviour between these systems and national economic systems as well as between different token economic systems. These differences will, as we will show, lead to important differences in behaviour between systems. The institutional-environmental factors promoting the accumulation and holding of token stocks in the two planned environments investigated here are summarized below.

In a therapeutic token economy for chronic psychotics, such as the Central Islip economy reported below, where tokens are valueless upon leaving the economy and patients are long-term residents, the environmental factors promoting the holding of token stocks are severely restricted when compared to the U.S. economy. The structure of such an economy obviates the need for building of equity funds for business purposes, establishing stocks of saving for retirement and/or anticipated future educational expenditures, etc. Further, the structure of such systems is generally such that there are no expensive (relative to normal income flows) consumption goods available for purchase and large stocks of tokens are not required to synchronize income and expenditure flows on a daily or weekly basis. Of the factors promoting holding of saving stocks in the U.S. economy, the only one generally operable is the establishment of a reserve for undesignated contingencies, that is, for a "rainy day." In addition, it has been suggested that patients in therapeutic systems accumulate tokens to avoid, for short periods of time, the contingencies of the token system while maintaining their consumption expenditures (Winkler, 1973) and also to display their relative income and wealth position within the economy.

In contrast, the structure of the token economy established for the purpose of experimentally investigating the socio-economic behaviour of volunteer subjects (Miles, *et al.*, 1974) results in marked differences between environmental conditions that promote the accumulation of saving stocks in effect both in therapeutic token systems such as Central Islip and in the U.S. economy. The distinguishing characteristics of this system with respect to saving behaviour are that tokens are convertible to currency in the national economy upon discharge, the period of confinement in the token system is relatively short, and wage rates approximate those of the national economy. In such a system all the factors promoting the establishment of saving stocks in the national economy are, in general, operative since the subjects will leave the experimental economy shortly with full convertibility of currency. In addition, the physical confinement to the ward in which the experimental economy was housed restricted the range of spending opportunities relative to the national economy and restricted most severely those spending opportunities for which stocks of saving are accumulated. Indeed, a majority of subjects stated that one of their primary reasons for enrolling in the experiment was to establish a saving stock to spend in some special way upon discharge.

Having specified differences in the factors promoting accumulation and holding of saving stocks in the Central Islip therapeutic economy, the Miles *et al.* experimental economy, and the U.S. economy, we now examine the effects of these differences on the income, consumption and saving relationships identified by Goldsmith in the U.S. economy and which have been widely studied in other national economic systems.

THE THERAPEUTIC ECONOMY

The Token System

The token economy in which the study was conducted was established in a female ward for chronic psychiatric patients at Central Islip State Hospital, a large hospital in New York. The token economy was the first stage of a series of programmes leading into the community. Patients progressed from the token economy to a Community Preparation Unit and hence to a follow-up programme. At the time the study was conducted the programme had been in operation for over a year.

Tokens were earned and spent over the usual range, e.g., tokens could be earned for self care, ward work, participation in activities, etc., and could be spent on canteen items, honour-cards, rentals, etc. (For a complete description see Battalio, Kagel, Winkler, *et al.*, 1972.) Most token expenditures during the study were spent on canteen items. There was no bank in the economy, hence all patient saving was in the form of token balances held in the patient's possession. Further, tokens were valueless upon leaving the economy.

Tokens were paper notes and also constituted a major part of the recording system (Logan, 1970). Notes ranged from 1-5 tokens. On each token, the staff recorded the date the token was earned, the name of the member of staff who gave the token, what the token was given for, and what type of good the token was spent on. A token could not be spent if all these records were not entered on the token. Once a token was spent, it was kept and could not be used again.

Measurement Procedures

Spent tokens, collected weekly and later sorted by resident name, provided the record for individual patient total expenditures. Re-sorting tokens by date earned, which was recorded on them, provided the record of individual patient income. Patients generally spent tokens one or two weeks after they were earned. This measure of patient income is subject to error primarily when patients do not spend tokens earned over the period in which spent tokens were collected, and when tokens that patients had earned are lost or destroyed. A check of these errors was obtained in an earlier study (Battalio, Kagel, Winkler, *et al.*, 1973) by recording total tokens dispensed by weeks. This record was obtained by having the ward psychologist provide the staff with a fixed number of blank tokens at the beginning of each shift and having the staff return the unused tokens at the end of each shift. When three or more weeks were allowed for the tokens to be handed in after they were earned, (as in the present study), the discrepancy between the two measures averaged 2.4% of the average value of the two measures, or a total of 119 tokens out of 5,005 tokens recorded as being handed out over a three-week period (Battalio, Kagel, Winkler, *et al.*, 1972, Table 3)[5]. It was not possible to trace the source of the discrepancies observed, which may have been a function of staff voiding tokens due to improper entry of required information, staff failing to return unused tokens, counting errors in recording tokens disbursed, or patients losing or not spending tokens.

Saving for a week is measured by the difference between income and total expenditure for that week. End-of-week stock of saving is calculated by adding weekly saving to the stock of saving held prior to the start of the study. This latter figure was calculated by summing all tokens spent during the experimental period but earned prior to it. The primary potential source of error in these data also stems from patients hoarding tokens. A check of these errors, also obtained in the earlier study, was made by having the ward psychologist directly check the number of tokens patients held during several mornings. By checking this record of token stocks against end-of-week stocks as measured by tokens handed in, we gained support for the evidence provided by the two independent income measures, that long-term hoarding of tokens was of negligible magnitude in the Central Islip economy.

Method of Study

Income, consumption and saving data reported below were obtained under an experimental procedure designed to study the effects of wage rate change on a non-competitive job, toothbrushing, and on general work behaviour in the token system. The weekly sequence of wage rate changes for toothbrushing are reported in Table I. The wages of all other token earning behaviours and the prices paid for consumption goods remained constant throughout the experimental period. A zero rate for toothbrushing had been in effect for two weeks prior to week 1 of Table I where our analysis begins. For some 20 months prior to this toothbrushing had been paid one token.

The subjects of the study were 28 patients who were on the ward throughout the duration of the experiment. All but one patient had been on the ward for three or more months prior to the beginning of the study.

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[5] Two-thirds of the patients in the present study participated in the earlier study.

TABLE I

EXPERIMENTAL DESIGN

Week	Tokens paid per toothbrushing[a]
1	0
2	0
3	5
4	0
5	1
6	0
7	5

[a] Toothbrushing was done once a day, 5 or 6 days per week, in the morning.

Results

Figures 1 and 2 provide a cross-sectional analysis of saving behaviour during the two weeks of baseline conditions.[6] Average per capita values of the stock of saving by income classes for weeks 1 and 2 are shown in Figure 1. The data presented in Figure 1 show increased per capita holdings of token stocks as incomes increase. Further, the token stocks held were a substantially greater percentage of income for the highest income class.

The data in Figure 2 show that average per capita saving flow in absolute terms (absolute saving), which measures the sum in absolute terms of positive and negative saving flows divided by the number of patients in each income class, increases uniformly as we move from lower to higher income classes. All of the patients in each income class except the lowest had either positive or negative saving flows during at least one of the weeks of the baseline period. Netting out the positive and negative saving flows in each income class, as also shown in Figure 2 (net saving), we fail to find a positive relationship between the magnitude of average per capita net saving and income. Furthermore, the magnitude of average per capita net saving conceals the magnitude of saving and dissaving taking place in each income class.

The positive relationship observed between end of week token stocks and income classes is analogous to the empirical relationship between net worth and income in the U.S. economy reported by Goldsmith. However, the cross-sectional relationship between average per capita *net saving* and income is, in this instance, quite different from that observed in the U.S. economy. In fact, during the time period examined, the highest income class is dissaving, as shown in Figure 2 where the net saving is negative. This marked difference is a direct consequence of the restricted set of saving motives in the token economy as compared with the U.S. economy. The incentives for continued, sustained positive saving in operation in the

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[6] The income classes were chosen on the basis of natural gaps in the distribution of income.

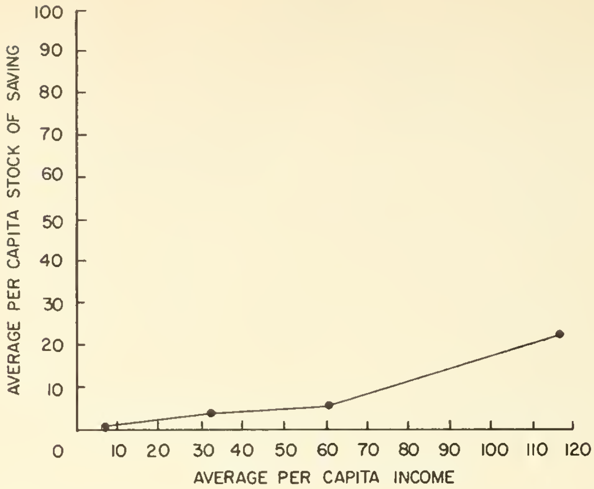

Figure 1 *Saving stock by income group: the therapeutic economy.*

U.S. economy, e.g., to provide a retirement fund or equity fund or to purchase expensive consumer durables, are clearly lacking in a therapeutic economy such as Central Islip. On the other hand the main motives in operation in the Central Islip economy, e.g., providing a reserve for undesignated contingencies, or to avoid the contingencies of the system while maintaining consumption, would imply a periodic building up and running down of saving stocks as this reserve is being established or used. Therefore, the cross-sectional relationship between income and net saving will depend on the relative number of patients in each income class who are building their stocks up, and on the magnitude of the buildup compared to those who are drawing their stocks down during a given time period. The positive relationship observed between end-of-week stock of saving and income is accounted for by the fact that the magnitude of the reserve needed to maintain consumption in the face of decreased earnings or temporary unavailability of jobs is a function of the consumption level attained which, in turn, is directly and positively related to the level of income earned.

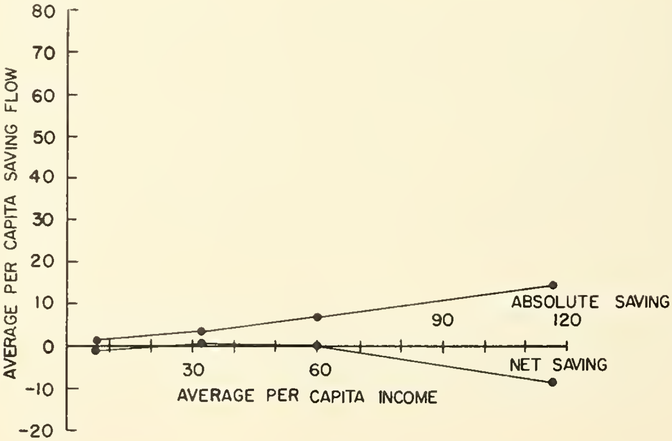

Figure 2 *Absolute and net saving flows by income group: the therapeutic economy.*

The aggregate per capita time series data of income and consumption support the conclusions drawn from the cross-sectional data concerning saving behaviour in the token system. Figure 3 presents these data for all seven weeks of the experiment together with a 45° line passing through the origin which contains the set of points where income equals consumption. The empirical data points all lie close to the 45° line indicating that for each week the value of aggregate consumption is close to income. This results in a value for aggregate net saving that is small in absolute value for each week, in no case exceeding 8.5 per cent of income. The aggregate time series counterpart to the conclusion that saving behaviour in the therapeutic economy is characterized by periodic additions to and subtractions from a non-negative stock of saving is found in the periodic variation of the data points around the 45° line. This indicates that positive aggregate net saving flows are periodically offset by negative net saving flows. These flows offset each other nearly completely during the experiment where the *total* net saving over the seven weeks was +3 tokens.

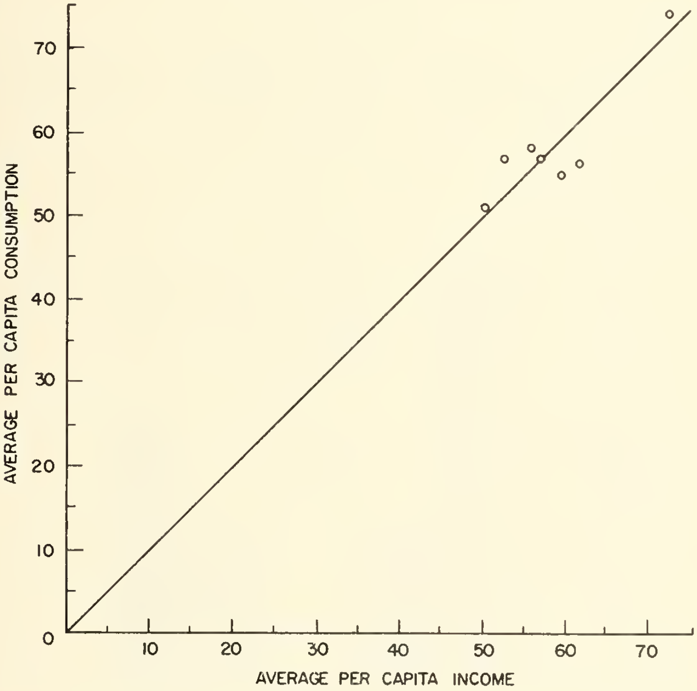

Figure 3 *Income and consumption over time: the therapeutic economy.*

The data shown in Figure 3 are in marked contrast to time series data on aggregate per capita income and consumption for the U.S. economy where most of the data points are found to lie below the 45° line, resulting in aggregate net saving that averages +11 percent of income over the long run. Further, those infrequent cases in which income has been observed to exceed consumption in the U.S. have been characterized by substantial and sudden decreases in income, e.g., during the Great Depression of the 1930's. Once again this difference in behaviour between the therapeutic token economy and the U.S. economy can be attributed to the limited saving motives in operation in the former as compared to the latter. Whereas in mixed capitalist economic systems there are incentives for continuous positive saving flows over extended periods of time, in a therapeutic economy where tokens have no exchange value upon release from the program, and release is frequently not a serious alternative within the time horizon of the patient, individuals have little to gain from continuously adding to their stock of saving.

The periodic additions to and subtractions from non-negative saving stocks that occur in the therapeutic economy are associated, in a definite way, with changes in patient's income levels. As the summary data in Figure 4 indicate, of those subjects whose token stocks changed between adjacent weeks of the experiment, increases in stocks (saving) were accompanied by increases in income between the weeks in question in about two thirds of all cases; while decreases in stocks (dissaving) were accompanied by decreases in income in about two thirds of all cases. This conclusion, that the proportion of dissavers is greater when incomes fall than when they are rising, is the same as that reported by Goldsmith (1955, Vol. I, pp. 5-6) for the U.S. economy. However, this behaviour occurs around a positive average saving ratio in the U.S. economy and a zero average saving ratio in the therapeutic token economy.

The relationships reported above, both cross-sectional and over time, have been replicated in the Central Islip economy under conditions of changing relative prices with wage rates held constant (Battalio, Kagel, Winkler, *et al.*, 1974).

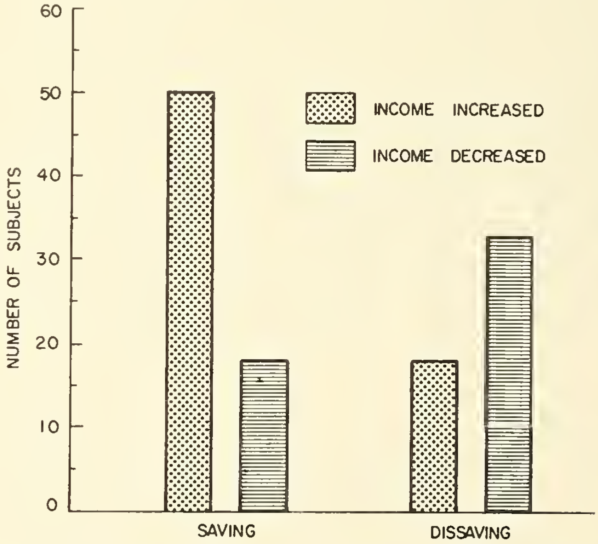

Figure 4 *Changes in income and associated changes in token stocks: the therapeutic economy.*

Discussion

Given the definitional relationship between stocks of saving and saving flows, a necessary corollary to the saving behaviour reported is that during the start-up phase of a token economy, or during the initial period of a patient's entry into an established token economy, income will consistently exceed consumption as patients generate the positive saving flows necessary to establish a positive net stock of saving which they will then increase or decrease as the situation warrants. Further, it follows directly from the stock-flow relationship and the premise that subjects hold token stocks for specific purposes; if subjects are fully aware in advance that a token system is to shut down or that they are permanently leaving it, consumption will consistently exceed income during the last days of residence while the patients spend tokens which are soon to become worthless. This last conclusion presupposes, of course, that there are no institutional restrictions on earning or spending that place a floor under earning or a ceiling on spending.

The conclusion reached from our analysis, that in a therapeutic economy, such as Central Islip, patients' saving behaviour will be characterized by periodic additions to and subtractions from some non-negative mean value of token stock holdings whose magnitude is a positive function of patient income, is similar to Winkler's (1972) assertion that there are critical ranges of saving stocks which vary among individual patients. Further, the data reported are also consistent with the income and consumption data reported by Winkler (1971) showing *daily* values for aggregate income and consumption over two 14-day periods in which aggregate net saving was approximately zero (Winkler, 1969, p. 217). The data reported there reflect the short term income-consumption behaviour resulting from the failure of receipts of income to exactly coincide with out-flows of expenditure on a daily basis, *i.e.*, saving behaviour in response to institutional-environmental factors (4) enumerated in the previous section. On days with low incomes, which occurred without exception on weekends when fewer token earning opportunities were available than during weekdays but the same consumption requirements and opportunities were present (Winkler, 1973b), consumption exceeded income and average net saving was negative. Correspondingly, on days with high incomes, which occurred exclusively during the week, income exceeded consumption as patients saved, building up their token stocks in anticipation of week-end conditions.

The present analysis corrects two important conceptual errors in Winkler's (1972) theory of equilibrium in token economies. The first is the stock-flow error noted earlier. The second is the use of the long-term consumption schedule observed for national economic systems to describe income and consumption behaviour in a therapeutic token economy. The only consumption schedule consistent with the long-term aggregate net saving rate of zero reported for the Central Islip economy is a consumption schedule passing through the origin with a slope (marginal propensity to consume) equal to one. This is in marked contrast to the consumption schedules found to organize the data for the U.S. economy which have positive intercepts on the consumption axis and a slope of about .9. Thus, while the observations motivating Winkler's theory of equilibrium (a tendency towards relatively constant income levels in a token economy in the absence of changing conditions) are left unaffected by our analysis, we must look elsewhere for an explanation of the behaviour observed. Such an explanation lies well beyond the scope of the present paper.

The analysis of income, consumption and saving behaviour presented also has relevance for planning more optimal therapeutic token systems. Any attempt to improve patient performance, as measured by the magnitude of income earned, by devaluing token stocks must clearly distinguish between short-term and long-term effects. Devaluation of patient token stocks can, at best, lead to increases in patient incomes only in the short term. If in the face of devaluation, patients maintain consumption of other commodities while building token stocks back up, the increased income flows responsible for the additions to stock will soon raise the level of stocks to the desired magnitude, at which time income will fall back to its original level in the absence of other changes in economic conditions. Continued maintenance of the increased income level without a corresponding increase in consumption would result in continued, indefinite increases in token stocks, something we have not observed in our studies. The important assumption in this short-term effect is that token stocks will be rebuilt by increased earnings rather than by decreased purchases of other goods. To the extent that token stocks are rebuilt by decreased consumption of other goods the short-term rise in income will be that much smaller. Continued periodic devaluations of token stocks can be expected to obviate any short-term beneficial effects on patient performance since patients would have strong motives for adjusting token stock holdings down to compensate for the anticipated devaluations. The long-term effects on income and consumption of periodic devaluations of token stocks is an empirical issue on which little evidence is presently available. The present analysis also indicates that permanent increases in patient consumption levels must soon be followed by permanent increases in token earning behaviours since increased consumption can only be financed from token stocks for a short period of time. Thus, attempts to increase patient performance by increasing the range and attractiveness of items that can be purchased will be successful, provided the new goods are consumed on a permanent basis and are consumed in addition to, and not in place of, the commodities already available for purchase in the economy.

THE EXPERIMENTAL ECONOMY

The Token System

The token system was established to investigate experimentally the socio-economic effects of long-term daily cannabis consumption. Using volunteer subjects, the economy was established on a floor of the hospital facilities of the Addiction Research Foundation of Ontario.

The study reported here is the third of three main studies, each of which lasted 98 days. Token earning behaviour consisted of weaving woolen belts on portable hand looms. There was no institutional limit on the number of belts a subject could produce and each completed belt turned in was paid for at a token rate equivalent to $2.50 in Canadian currency. By the middle of the study the average productivity approached 1 belt per half hour.

A bed, cleaning services, heat and light were provided free to all subjects. All other items were paid for by the subjects with tokens. Items available for purchase on a regular basis were alcoholic beverages, soft drinks, regular cigarettes, candy, etc., all of which were sold from a token store open continuously on the floor; use of recreational and entertainment facilities; main meals from the hospital cafeteria; snacks from the hospital canteen; carry-in food orders from outside; and trips outside the hospital in the company of staff members. In addition, one staff member was engaged full time in buying special order items of virtually any kind for the subjects. The costs of goods and services purchased were generally matched to prices prevailing in the Canadian economy. Any token stocks saved up at the end of the experiment were directly convertible into Canadian currency with no loss in value. A bank was provided for holding unexpended token stocks but it did not pay interest.

Subjects remained residents of the economy continuously for the duration of the experiment. A $200 end-of-study bonus was paid to all subjects completing the study. In addition, withdrawal from the experiment prior to completion was penalized by forfeiture of three-quarters of all earnings. (For additional information on the structure of the economy see Miles *et al.*, 1974.)

Measurement Procedures

The record of subject income is obtained from daily records of acceptable belts handed in, multiplied by the belt rate of $2.50. A running tally of belts handed in was maintained at the point of exchange (the nurses' station on the floor) and was double checked and corrected by two staff members at the end of each shift. Daily summaries of belt production were checked and reconciled with an independent record of belts handed in which was maintained as part of a collateral study. No independent record of tokens disbursed in return for belts produced was maintained.

The record of subject expenditures is taken from daily purchase sheets on which the staff recorded the article purchased and its cost at the time of exchange. These records were also double checked by two staff members at the end of each shift to correct for errors and omissions. A partial check on the accuracy of these data was provided by collecting tokens spent and comparing them with the purchase sheet totals.[7] In the event of irreconcilable discrepancies between the two records, purchase sheet observations were used. For each subject of the present study the total of such discrepancies amounted to less than 1 percent of total expenditures of that subject.

End of experiment stock of saving is the record of money actually paid to subjects, less bonuses, upon leaving. These data provide a check on the accuracy of the income and expenditure data since the end of experiment stock of saving should equal saving as measured by subtracting total expenditures from total income. Any discrepancies between the two measures of saving may be attributed to irreconcilable errors in the expenditure data, lost or borrowed tokens, or undetected errors in measuring income and expenditures. The differences between the two measures of saving taken as a percentage of subject income range from 6 per cent to 0 per cent, with an average value of 2.4 per cent.

Method of Study

The subjects reported on are 10 young women who constituted an experimental group and lived together on a closed ward of the hospital. The ages of the subjects ranged from 18 to 25 years with an average of 20.8 years. All had completed a high school education or beyond. Further, all subjects had certified that they had used marijuana prior to the experiment and had been screened to eliminate hard drug users and emotionally unstable individuals. Six of the ten subjects listed money as a primary reason for volunteering for the experiment.

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[7] The tokens collected only provide a partial check on the accuracy since there is some evidence that the staff may have removed or added tokens prior to submitting them in an attempt to attain the consistency they knew the research assistants were checking for.

The experimental design employed in studying the effects of marijuana on this group was an ABA sequence with a baseline of no marijuana available and an experimental period in which unlimited amounts of 2 mg Δ^9–THC cigarettes were available for purchase at all times at $.50 each. Subjects were given $15 spending money over the first three days of the experiment to live on until they learned how to weave belts. Thereafter they were dependent on belt production for income. Aside from the introduction and withdrawal of an additional consumption good, marijuana, there were no other systematic or major changes in economic conditions throughout the course of the experiment.

Results

In Figure 5 we show average per capita income and consumption for the economy for each of the 14 weeks of the experiment together with a 45° line through the origin which shows the set of points where income equals consumption. The empirical data points all lie well below the 45° line, indicating that aggregate income is substantially larger than aggregate consumption, resulting in large positive net saving flows throughout all weeks of the study. The consistent positive saving flows reported for the aggregate data are representative of individual behaviour since 7 of the 10 subjects are reported as dissaving in at most one week of the experiment while the 3 remaining subjects had the lowest income earnings of the group. The data further indicate that the level of income plays only a small part in determining the level of consumption, *i.e.*, increases in income are matched by substantially smaller increases in consumption and large increases in saving.

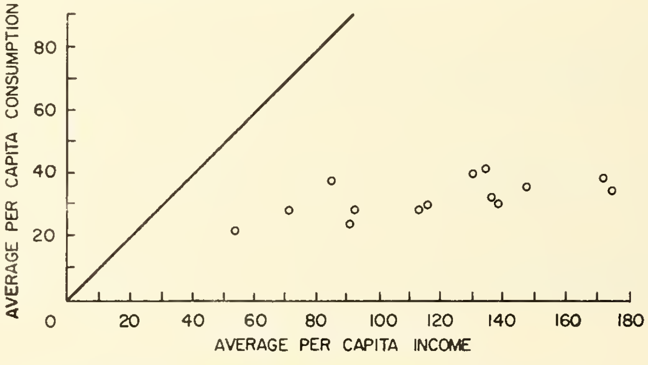

Figure 5 *Income and consumption over time: the experimental economy.*

These aggregate per capita income and consumption data stand in marked contrast to similar observations for both the therapeutic token economy and the U.S. economy. Whereas in the therapeutic economic system the data points are all found lying close to the 45° line with aggregate net saving flows averaging zero over the long run and in the U.S. economy the data points are generally found lying somewhat below the 45° line with aggregate net saving averaging about +11 per cent of aggregate income over the long run, in the experimental economy the data points all lie well below the 45° line and aggregate net saving averages +65 per cent of aggregate income over the course of the experiment. The high rates of saving observed in the experimental economy can be attributed to the convertibility of unspent tokens at the end of the experiment, which was well within the planning horizon of the subjects, and the relatively high piecework rate for weaving belts which allowed subjects to readily attain and surpass subsistence income levels.

The cross-sectional counterpart to the time series data are presented in Figure 6 where we show the relationship between individual saving and income, measured over the whole experiment for the 9 subjects who successfully completed the program. As in the U.S. economy the positive net saving flows of the economy are largely attributed to the highest income earners. Since the flow of saving over the experiment equals, by definition, end of experiment stock of saving exclusive of bonuses, Figure 6 also depicts the relationship between income earned and end of experiment stock of saving.

We have also drawn into Figure 6 a straight line fit to the observed data points by the method of least squares and a 45° line passing through the origin which represents the locus of points such that saving equals income; *i.e.*, the locus of points for which consumption is *zero* during the experiment. The two lines are nearly parallel, with the least squares line intersecting the income axis at a value of about $494. The relationship between the two lines and closeness of the data points to the least squares line indicates that virtually all income earned by the subjects beyond $494 goes to saving. This income-saving relationship is the counterpart to the time series data for income and consumption shown in Figure 5 where the average per capita weekly consumption was seen to be relatively constant and unresponsive to the level of weekly income earned.

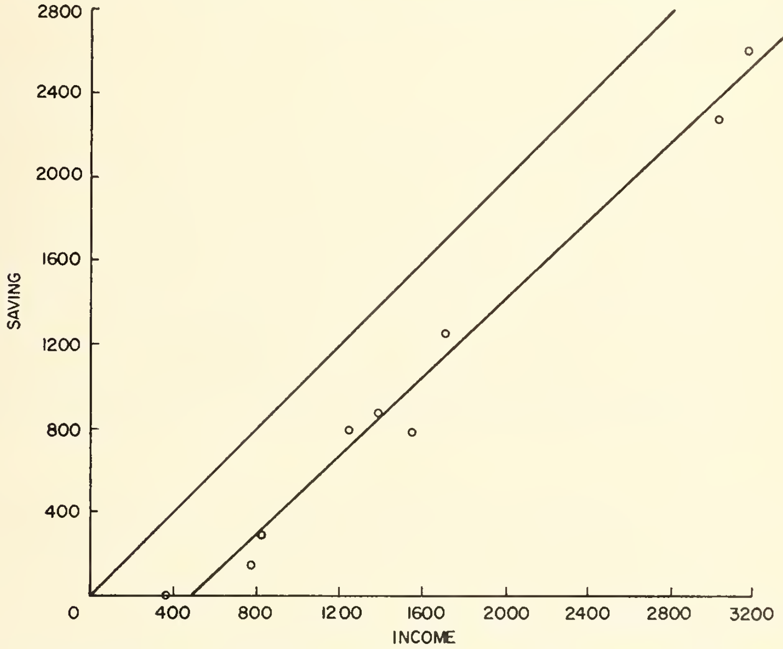

Figure 6 *Income and saving of individual subjects: the experimental economy.*

While we have not presented an analysis of the effect of changes in experimental conditions, *i.e.*, marijuana availability on saving behaviour, we are not asserting that marijuana has no impact on income, consumption and saving behaviour. However, the magnitude of the differences in the saving relationship with and without marijuana are small relative to the differences in behaviour between the experimental economy and the therapeutic economy as well as the U.S. economy and consequently, analyses of these differences are omitted.

The income, consumption and saving behaviour reported has been replicated by other groups living in the same or a similar experimental economy (see Miles, Battalio, Kagel, and Rhodes, 1975).

Discussion

Saving behaviour in the experimental economy has been found to be characterized by high and sustained rates of positive saving flows that were most heavily concentrated among the higher income earners. The key institutional-environmental factor identified as shaping this behaviour is that unspent tokens were fully convertible to Canadian currency within a relatively short time horizon. Consequently, all the saving motives in operation in the national economy were in operation in the experimental economy. In addition, the activities associated with spending these stocks of saving were in some cases only realizable outside the experimental economy and in other cases more fully realizable in the national economy.

CONCLUSIONS

Our re-examination of income, consumption and saving behaviour in token systems has resulted in finding substantial differences, as well as similarities, in behaviour both across different token systems and in the United States economy. Citing factors specified by empirical economists as affecting the accumulation and holding of saving stocks in national economic systems, we have been able to reconcile these differences as reflecting differences in the structure of the environment within which the behaviour took place. Utilization of concepts developed by empirical economists to describe behaviour in national economic systems has led to an increased understanding of income, consumption and saving behaviour in token economic systems which would have been much more expensive, in time and resources, to attain otherwise.

The results of the analysis presented here must be reckoned with in designing experiments in token systems and in comparing results of experiments across different economic systems. The ability to save in a controlled environment introduces interdependencies between behaviour over time. These interdependencies, unless fully recognized, can lead to serious errors in the interpretation and evaluation of experimental results as noted elsewhere in this volume (Battalio, Kagel and Winkler, 1975).

For economists, a thorough understanding of the behaviour investigated here is of primary importance in understanding, predicting and controlling behaviour in national economies. The relationships between income, consumption and saving are, within the framework of the Keynesian economic theory adhered to by many modern economists, of crucial importance in determining the equilibrium level of Gross National Product, unemployment and rates of inflation in advanced industrialized economies. In underdeveloped countries the issue of how to promote adequate levels of saving flows necessary to attain the investment flows required to expand the productive capacity of the economic system is of primary importance. Controlled environments explicitly developed for the study of economic behaviour have an important and, as yet, unexplored role to play as laboratories for controlled investigation of these behaviours as well as wide classes of other behaviours of equal importance to professional economists.

ACKNOWLEDGEMENTS

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Analysis of Individual Behaviour in Controlled Environments: An Economist's Perspective

Raymond C. Battalio[1], John H. Kagel, and Robin C. Winkler

INTRODUCTION

For the past two-and-a-half years we have been engaged in cooperative research in studying economic behaviour in token systems (Kagel and Winkler, 1972; Battalio, Kagel, Winkler, *et al.*, 1972, 1973 a,b; Kagel, Battalio, Winkler, *et al.*, 1975.). In conducting this research we have identified marked differences between the conceptual framework used by economists and the framework used by behavioural psychologists. It is our purpose in this paper to begin to formalize the conceptual framework used by experimental economists and to show, through examples from our research, the additional insights into understanding individual behaviour in controlled environments stemming from the concepts employed. In order to avoid any misunderstanding at the outset, we emphasize that our contention is simply that the concepts employed by economists can add to the understanding of individual behaviour achieved by behavioural psychologists and, as such, complement, rather than substitute for, the traditional concepts employed by behavioural psychologists.

There are two areas for economic research in controlled economic systems. First, as functioning economies these systems provide economists with unique opportunities for controlled observation and experimental analysis of aspects of economic behaviour which are primarily of importance in understanding and controlling economic behaviour in national economic systems (Kagel 1972, Kagel and Winkler 1972). For example, experimental controlled environments can serve as laboratories for the study of the effects of inflation on both labor productivity and consumer purchase behaviour. The importance of extending behavioural research techniques in this direction has long been recognized by behavioural psychologists (Skinner 1953). Second, experimental economists can aid in analyzing economic aspects of whole classes of behaviours in controlled environments which are primarily of interest to psychologists and psychiatrists. For example, as demonstrated below, research aimed at understanding the working and consumption behaviour of chronic alcoholics or regular cannabis users, including consumption of the drug in question, can be considerably enriched by employing concepts of economic analysis. The basis for contributions in this second area stems, simply enough, from the fact that token economies are functioning economic systems and, as such, have the properties and characteristics of such systems. Consequently, behaviour in these systems is, in part, shaped by economic contingencies, *i.e.*, the economic structure of the system and the economic variables. Although we have designated two different areas of research within controlled economic systems, there is, of course, no hard and fast separation of the two areas specified. While, from the viewpoint of experimental economists, the potential for developing an empirical theory of economic behaviour constitutes the primary motive for cooperative research efforts in controlled environments,[2] given the purpose of this symposium and the primary research interests of the participants, this aspect of our research is not discussed here. Rather, the discussion presented will focus on aspects of economic behaviour that are of direct relevance to psychologists and psychiatrists whose primary interests are other than extending behavioural research to the study of economic behaviour per se.

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In the next section of the paper we outline the conceptual framework employed by economists in studying behaviour in controlled economic systems. This framework is then applied, in the following two sections, to the analysis of behaviour in several experimental studies we have been associated with.

CONCEPTUAL FRAMEWORK

Economists view an economic system as an interconnected whole in which a change in one part of the system may affect behaviour in all parts. The interdependencies postulated can be conveniently classified into two categories. First, interdependencies exist between the variables of the system within any given observation period. Consequently, a change in one element of the environment has an effect not only on a narrow class of target behaviours but on all activities within the system. For example, changing the wage rate on a particular job, Job A, has an effect on both the frequency with which the target behaviour A is performed and, via the changes in relative wages and income, also influences the performance of other jobs and consumption within the period of observation. Second, interdependencies exist across observation periods. The behaviour during one time period affects behaviour in future observation periods while anticipated conditions in future time periods feed back and affect present behaviour. For example, if individual income earnings exceed spending in one time period there will, eventually, result a period in which spending exceeds income.

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[2] See, for example, Kagel (1972) and Battalio, Kagel, Winkler, *et. al.*, (1973a).

Economic behaviour, as characterized by economists, depends on a basic "n-tuple" of variables. These are the set of jobs performed, or behaviours, which receive monetary (token) rewards, the set of goods and services which have a token price, the money wage rates of the jobs and the prices of the consumer goods. In addition, the set of goods and services provided free of cost as well as the set of activities available to perform which do not receive token wage payments also affect economic behaviour. Also, widening or narrowing the set of jobs, the set of consumer goods or the set of non-pecuniary activities and free consumer goods affects behaviour throughout the system. While it is apparent from reading the token economy literature that psychologists and psychiatrists are aware of these interdependencies, it is equally clear that these systemic effects do not form a central framework of analysis as they do for the economist. The secondary role given these interdependencies in the analysis of experimental results leaves, as we will demonstrate below, many questions unanswered which are of primary importance to psychologists and psychiatrists. Further, the failure to consider these interdependencies fully has led to conclusions which are unwarranted on the basis of the experimental evidence presented.

INTERDEPENDENCIES WITHIN AN OBSERVATION PERIOD

In this section we examine the nature of the interdependencies within a given observation period associated with a change in wage rates and prices. We begin with an analysis of the interdependencies associated with a change in a single wage rate while keeping all other wage rates and prices constant.

The study reported was conducted in a therapeutic token system for female psychiatric patients in the Central Islip State Hospital. The range of consumption goods in the economy included canteen items, a private room, lockers, off-ward passes, etc., and the income earning activities ranged from self-care activities to janitorial type jobs. The token economy had been in operation for about two years at the time of the study and about half of the patients had been part of the economy for over six months. The available set of consumption goods did not include any goods that were expensive, relative to normal income flows, and no savings institution was provided. Over any extended period of time the aggregate level of consumption was approximately equal to earnings, which implies that any sustained increase in income earning was associated with a sustained increase in consumption expenditures. (A more complete description of the economy, the experimental design and saving behaviour is contained in Kagel, Battalio, Winkler, *et al.*, 1975).

In the experiment conducted, the token wage rate for toothbrushing was systematically varied for one week at a time, beginning with a four week baseline of a 0 token wage rate, in the following sequence: 5, 0, 1, 0, 5 tokens. Previous to the baseline period toothbrushing had received a 1 token wage rate. The toothbrushing activity was scheduled so as not to conflict temporally with other income earning or consumption activities. The overall wage and price structure was such that a 5 token wage rate for this job, requiring 3-5 minutes daily, was quite "high" in the sense that during the baseline period the average per-capita level of income earned was 51 tokens per week with one-third of the patients earning less than 25 tokens, the amount which could be earned by utilizing all the available toothbrushing opportunities during the first 5 token wage week.

The changes in the target behaviour, toothbrushing, are shown in Figure 1. The percentage of times this job was worked is positively related to the magnitude of the toothbrushing wage rate — a result consistent with earlier token economy research.

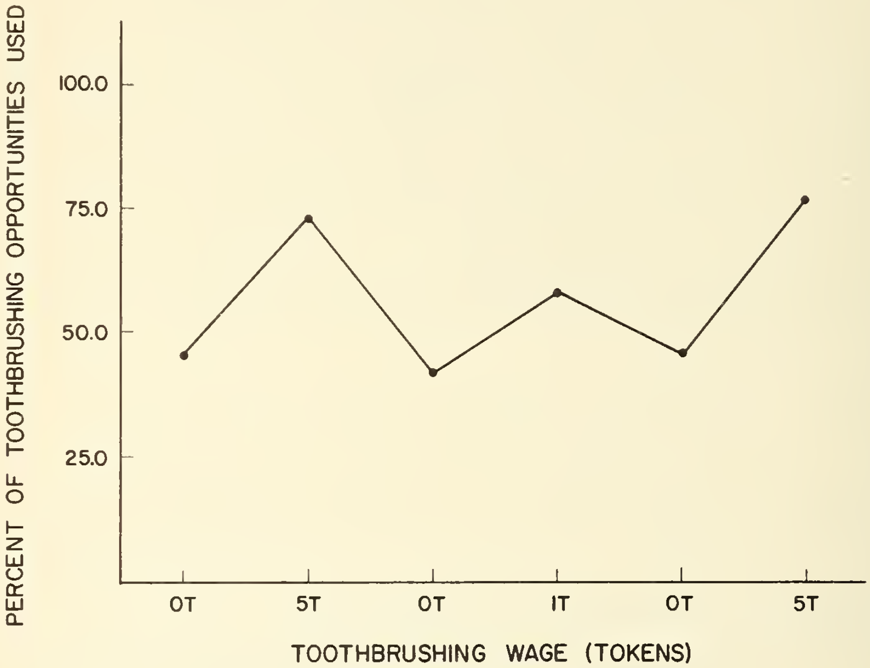

Figure 1 *Changes in toothbrushing behaviour.*

In addition to the change in the absolute, or token, wage rate the change in the toothbrushing wage rate also resulted in a change in relative wages between this job and all other jobs, *i.e.*, the wages for all other jobs decreased *relative* to the wage for toothbrushing when the wage rate for toothbrushing was increased. This change in the relative wage rates introduces an interdependency between the level of performance on toothbrushing and the level of performance on all other jobs. The nature of this interdependency can be seen by an examination of Figure 2, which shows the average level of total income earned, by income classes, for the first two weeks shown in Figure 1.[3]

As is clearly indicated by the data in Figure 2, the increase in relative wage rates for toothbrushing resulted in considerably reduced performance of other income earning activities for the high income individuals.[4] While these individuals had sub-

[3] The income classes, each of which contain between 6 and 8 individuals, were selected on the basis of natural breaks in the empirical income distribution. The income classes, which are specified using the token income level for the last baseline week, are: 1, 0 ⩽income ⩽10; II, 12 ⩽income ⩽32; III, 39 ⩽income ⩽83; IV, 102 ⩽income ⩽148.

[4] The percentage of toothbrushing opportunities used during the two weeks shown in Figure 2, are, by income classes given in footnote 3: I, 50-45; II, 38-82; III, 41-84; IV, 59-89. Two S's, who earned 0 total tokens during the week toothbrushing wages were zero, showed a decrease in toothbrushing. In the second 0-5 T sequences they each showed improvement of 33%. The corresponding data for the second 0-5 T sequence is I, 34-53; II, 36-73; III, 62-84; IV, 61-100.

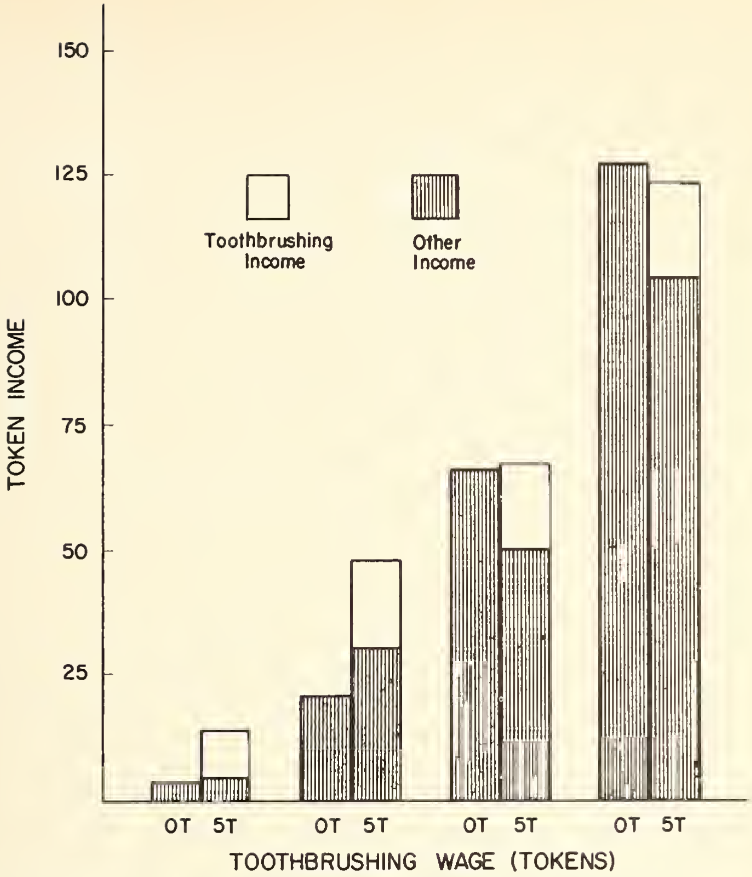

Figure 2 *Average level of total income earned, by income classes.*

stantial earnings from toothbrushing, the change in the average level of total income earned was small with the increase in toothbrushing earnings being matched by a decrease in other income earning activities. Only two individuals from the top twelve did not reduce their other income-earning activities. In marked contrast, with the increase in toothbrushing wages individuals in the lower two income classes responded to the wage increase primarily with an increase in total earned income. For these two income classes the average change in earned income was equal to or greater than the level of toothbrushing earnings and hence, there was no reduction in other income earning activities.[5]

While psychologists have long been aware of the mutual interrelatedness between alternative jobs as well as between "high" wages for one job and performance on other income earning activities, the implications of this mutual interdependence are often overlooked and the total income data, such as shown in Figure 2, are seldom presented when analyzing the effects of a wage rate change on behaviour. In view of the interdependencies exhibited by the upper income earners, whereby one source of income earning activity was substituted for another with little change in total income earned, an analysis of changes in the total level of income earning activities together with an examination of changes in the level of the target behaviour, are necessary to evaluate the overall consistency of a given change in the wage structure with the overall goals of the economic system. If the goal in increasing toothbrushing wages in the above study was to increase the level of the target behaviour, toothbrushing, then a detailed analysis of the target behaviour alone would be sufficient. If, however, other goals of the economy place importance on maintaining the performance level of other activities or on increasing overall activity in addition to increasing toothbrushing activity, then it is only by examining the level of overall behaviour that the full impact of the wage change on individual behaviour can be discovered. The data in Figure 2 demonstrate that increased wages on one job and the associated increases in earned income from this job will, under appropriate circumstances, result in a substantial reduction in the level of performance on other income earning activities.

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[5] The increase in other income earned by the lower income classes is explainable, in part, by the institutional structure of the economic system studied in which limitations on staff time and other resources restricted the available opportunities to work each designated income earning job. In this context, the failure of lower income individuals to participate in very much income earning activity during the zero token wage week may have resulted from shortages of those particular jobs in the economy for which the magnitude of the wage payment was sufficiently large, relative to the work effort required, for them to engage in the activity. Under these circumstances the increase in other token earnings during the five token wage week may reflect the availability of such jobs as a result of the upper income earner's decision to work fewer other jobs during this week. However there was sufficient flexibility in the system for all of the subjects to simultaneously increase their incomes by at least 5 to 10 tokens per week (about 10-20% of the mean subject income).

The increases in total earned income during the 5 token wage week by the individuals in the lower two income classes were primarily associated with increases in consumption rather than saving. In contrast, the upper income groups maintained a constant average consumption level along with a constant income level between the two weeks. In other words, the lower income groups responded to the increase in toothbrushing wages primarily by earning greater levels of income and consuming more goods and less non-income earning activities, leisure, while the upper income groups kept income about the same and consumed primarily more leisure and about the same level of goods. The relatively higher value placed on increasing goods consumption by the lower income subjects is entirely consistent with the concept of satiation introduced by Ayllon and Azrin, where satiation is characterized in terms of the range of consumption goods available, relative to income-earning activities, since within the Central Islip economy there was much more room for increasing consumption, both by consuming different goods and by increasing the quantity of goods already being consumed, for those individuals with relatively low initial levels of consumption. This contrasting behaviour points out the functional interdependency between income earning and consumption widely recognized by practising psychologists in token systems as evidenced by the continuing emphasis placed on introducing new goods into the economy and familiarizing patients with the goods already available for consumption.

The analysis of the effects of wage rate changes helps to explain the failure of self-care activities to decrease by very much when tokens were made non-contingent, in the study by Ayllon and Azrin (1968, pp. 238-256). In that economy during the contingent procedure, self-care activities were paid a wage rate of one token. This wage rate was both relatively low with respect to other wage rates and low in absolute terms with respect to the mean level of weekly income of about 150 tokens. In this context, the relatively small decline in self-care activities when tokens were made non-contingent may be explained in terms of the low contingent wage rate of these activities, which may have resulted in a level of performance that was not very much above the level associated with a zero wage rate to begin with. As the data in Figure 1 show, this was the case for toothbrushing in the Central Islip economy between the zero and one token wage weeks. Further, Ayllon and Azrin (1968, pp. 114-115) have demonstrated that performance of at least one self-care activity, physical exercise, will decline substantially under a zero token wage rate as compared to performance when the relative and absolute wage rates are substantially higher than the one token wage rate reported above.

The interdependencies associated with a change in the price of a single commodity are similar to those associated with a wage change. One effect of lowering the price of a target commodity is to change the quantity purchased of that commodity. In addition, lowering the price of one commodity while all other prices are held constant results in changing the relative prices of the entire set of consumption goods compared to the good for which the price was changed. For example, lowering the price of milk while keeping the price of soda constant makes soda relatively more expensive in terms of milk. This change in the relative price structure will often result in a substantial change in the consumption of those goods for which prices were not changed.

The fact that expenditure on one good is related to expenditure on all other goods has important implications for determining whether a sampling procedure for increasing the consumption of a single good in the economy is effective in increasing overall activity levels. While reinforcer sampling studies have demonstrated that it is possible to increase consumption of a target good through the use of a sampling technique, these studies do not present any data on the level of total consumption expenditures. The increase in consumption, and expenditure, on the target good can be accompanied with either an increase or a decrease in the level of expenditure on other goods, which can, in turn, result in either an increase or decrease in total expenditures and, consequently, earned income. Therefore, if reinforcer sampling procedures are presented as a method for increasing overall activity, then data for the level of total expenditures as well as for expenditures on the sampled commodity must be presented, something which has not been done in the studies reported.

In addition to changing the relative price structure, a change in the token prices, while token wages remain constant, also changes the real wage rate by changing the quantity of goods available for working a given job. The change in real wages associated with the change in token prices can, just as when the token wage rate changes, result in a change in the level of income earning activities. In a previous study conducted in the Central Islip Token Economy, the token prices of a collection of consumption goods were systematically varied while keeping token wages constant, with part of the goods having price increases and part decreases (Battalio, Kagel, Winkler, *et. al.*, 1973b). For those individuals with consumption expenditures concentrated on the set of goods for which prices were lowered the change in prices constituted an increase in their real wage rate. That is, for these individuals each job worked at the same token wage rate resulted in a greater level of goods consumption due to the token price decreases. Therefore, the previous level of goods consumption could be maintained, or even increased, with a decreased level of income earning activity. An examination of the effects of price changes on income earning activities, by income classes, yielded results similar to those shown in Figure 2 for the toothbrushing study. In both cases an increase in the real wage, whether by increasing the token wage rate or by decreasing the price of the goods consumed, was associated with the upper income groups decreasing their income earning activities while the lower income groups primarily increased their level of goods consumption with little or no decrease in income earning activities.

INTERDEPENDENCIES ACROSS OBSERVATION PERIODS

Economic behaviour in token systems is interdependent across observation periods as well as within a given observation period. These interdependencies occur any time a stock of saving can be carried across observation periods. By saving and building up token stocks in one time period, consumption can be deferred from the period of stock buildup to a later, perhaps more convenient, period of time. Or, another way of viewing the same behaviour, by having income exceed consumption in one time period the work activity necessary for future consumption can be done in the present allowing for more leisure in the future or for anticipated future unemployment while maintaining consumption levels. Economic interdependencies over time are most clearly apparent when dissaving occurs, as this behaviour typically cannot occur within controlled environments unless income has exceeded consumption during some prior period.[6] While evidence of these interdependencies over time abound in the token economy literature, the full implications of this behaviour in evaluating the outcomes of experimental studies have been ignored.

The observations on daily income and consumption behaviour reported by Winkler (1971) provide a clear example of the interdependence of economic behaviour over time in a token economy. The structure of the economy under which the observations were collected was such that although consumption opportunities remained at much the same level during weekdays and weekends, job opportunities dropped off sharply on weekends. The response to this structure was for patients to consistently earn higher incomes on weekdays which they saved to spend on weekends (Winkler, 1973). Thus, consumption over the weekend was maintained in the face of sharply reduced token earning opportunities and the situation was anticipated and planned for by increased earnings and savings on weekdays.

Interdependencies over time are a central feature of much of the work-contingent alcohol research (Nathan, *et al.*, 1970, 1971, 1972; Mello and Mendelson, 1972) and help to explain the income-earning and alcohol consumption patterns reported in the literature. The experimental design used in these studies has a baseline condition in which no alcohol is available but during which points can be earned for future alcohol consumption or for purchase of at most one other commodity (time out from isolation (Nathan, *et al.*, 1970, 1971, 1972) or cigarettes (Mello and Mendelson, 1972)) either during baseline or later in the study. The experimental condition following the baseline period consists of unlimited amounts of alcohol available for purchase with the same token-earning opportunities and alternative consumption opportunities as under baseline conditions. The work-alcohol consumption pattern reported during the experimental phase of all the studies cited shows an initial drinking spree during which subjects slow down or completely stop their operant responding for varied lengths of time. Subjects only resume operant work when they are completely out of points or in imminent danger of running out.

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[6] We have assumed that no borrowing is possible in the economy, which is typically the case in planned environments.

To abstract from the commodity actually investigated, alcohol: the economic contingencies of the experimental designs used in these studies are such that a subject is first allowed to work with, at most, one immediate consumption opportunity under the full knowledge that in a short period of time a highly preferred consumption good, whose consumption and after effects are of relatively long duration, will become available. Further, the after effects associated with the consumption of this commodity may well interfere with optimal job performance.[7] Under this experimental design, working and saving during baseline, followed by dissaving and consumption of the highly preferred commodity under the experimental conditions, is largely a response to the specific economic contingencies rather than a response to the special pharmacological properties of the commodity under investigation.

The effect of the economic contingencies on the working and drinking patterns observed is indicated by the contrasting results obtained in another study of alcoholics' work-contingent behaviour (Mello, *et al.*, 1968). In this study the period of drinking was not preceded by a baseline during which points could be earned for future drinking. During the drinking period the subjects had the choice of working and saving to finance periods of any duration desired of extended drinking without work or of closely matching working and drinking. Under these conditions virtually all subjects are reported as closely matching earned income and drinking, with only enough work being performed prior to each period of drinking to purchase an average of between 1 and 3 ounces of alcohol (the operant task had a reinforcement value equivalent to 1/3 ounces of alcohol). Few instances of spree behaviour, *i.e.*, extended periods of drinking during which little work performance is done, were reported.[8]

The interdependence of economic decisions over time is present in all alcohol and drug research in which the drug is unavailable during baseline conditions. Under these circumstances, an essential question is: to what extent are the behaviours observed a function of the pharmacological properties of the drug studied or the behavioural syndrome characterizing the consumption of the drug, rather than a result of the economic conditions under which the drug is made available? Since the economic interdependencies result, at least in part, from the non-drug properties of the commodities studied which are common to other goods (*i.e.*, their lengthy consumption and after effects which partially interfere with working), part of the answer lies in experimental studies of the work-consumption behaviour of subjects who are heavy consumers of other time-intensive goods such as reading, painting, or watching T.V. Such studies would follow the same ABA experimental design as the alcohol and drug studies except that the commodity introduced and withdrawn would not be alcohol or cannabis but, rather, some other time-intensive item which the subjects under investigation consumed in large amounts in the national economy. Another part of the answer to the question lies in further study of the behaviour of alcoholics and regular cannabis users under different and changing economic conditions. For example, what would be the effects in the alcohol studies cited of an enlarged alternative consumption set, of making consumption of all goods work-contingent, or of changing the institutional structure under which work was performed? Such studies would have as a primary focus the goal of identifying economic factors which lead to, or help alleviate, some of the more undesirable effects of alcohol or drug use.

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[7] For a more complete discussion of this point see Miles, Battalio, Kagel and Rhodes (this volume).

[8] The extreme sensitivity of alcoholics' work-alcohol consumption patterns to the economic contingencies of the experimental design is further evidenced in Experiments 1 and 3 reported by Nathan, *et. al.*, (1971). In Experiment 1 the subjects knew the length, duration and timing of each experimental condition from the outset while in Experiment 3 the subjects were not informed as to when periods of alcohol consumption would be available or their durations. Although both studies followed the ABA design discussed in the text, under conditions of certainty as to the time drinking would begin point earnings were evenly distributed over the 6 days of the initial baseline whereas under conditions of uncertainty total baseline point earnings were almost entirely concentrated in the first two days of the baseline condition (which lasted for 9 days) with the first day earnings of the lowest earner substantially exceeding the maximum earnings for any day of any of the subjects under conditions of certainty. Thus, when it was uncertain when alcohol would be introduced subjects immediately established a stock of points while when they were certain as to when alcohol was to be introduced they distributed their work more evenly over the baseline period gradually building up the stock of points for future use.

Economic interdependencies over time also extend to the post-experimental period whenever unexpended stocks of saving are convertible into currency of the national economy upon discharge from the controlled environment. The shorter the stay in the controlled environment and the larger the magnitude of stocks attainable relative to extra experimental income and wealth, the stronger the interdependencies between experimental and post-experimental periods. Inability to convert end of experiment earnings or small potential earnings breaks or weakens these interdependencies. Income and consumption behaviour during an experiment varies significantly with changes in these interdependencies (Kagel, Battalio, and Winkler, *et al.*, 1975). If unspent tokens are not convertible into government money at the end of an experiment, consumption will closely match income over the entire experimental study and subjects will leave with few, if any, unspent tokens at the end of the experiment. This behaviour follows directly from the fact that tokens are not earned for their own sake but rather for the primary reinforcers for which they are exchangeable. However, when unspent tokens are convertible into currency of the national economy at the end of an experiment, the subject who leaves the experiment with a quantity of unspent tokens is able to consume at a greater level and/or work less than otherwise when he returns to the national economy. In this case accumulation of large amounts of unspent tokens over the experimental period is entirely consistent with the fact that tokens are not earned for their own sake but rather for what subjects can purchase with them.

Psychologists and psychiatrists have failed to fully account for post-experimental interdependencies in evaluating the results of experiments in controlled economic systems. For example, Mendelson and Meyer (1972), in reporting the results of a study of heavy and casual cannabis smokers, note that the most significant feature of the subject's work behaviour was in comparison to the results obtained in alcohol-related research. They state, "The most significant feature of this (work) behaviour was that, almost without exception, every subject earned the maximum number of reinforcement points every day in both studies. This finding is in marked constrast to results obtained in alcohol-related research in which alcoholics have periodic, complete cessation of work output when they are consuming alcohol." (Mendelson and Meyer, 1972, page 94.) The implications of the contrast – that the differences reported are a function of alcohol vs. cannabis consumption – are however, unwarranted in view of the differences in economic interdependencies between the experimental and post-experimental periods in the studies referred to. In the cannabis studies unexpended end of experiment points were convertible into currency of the national economy upon completion of the experiment. In addition, there was a limit placed on the maximal allowable earnings in any day that was equal to about double the average daily cannabis expenditures of the heaviest smoker. In contrast, in the alcohol-related research (Mello and Mendelson, 1972)[9] no limit was placed on daily earnings, and unexpended points were valueless at the end of the study. In this context it is interesting to note that in the alcohol-related study, subjects using an operant manipulandum similar to that used in the cannabis studies frequently earned more points in a given day than the maximum allowable in the cannabis studies. This behaviour occurred during both baseline and drinking conditions. However, having established a store of points the subjects began a period of drinking during which little or no work was performed, which is totally explainable by the fact that there was no incentive for sustaining the high earning rates since any points not spent by the end of the study would be worthless. Under these circumstances any attempt to identify differences in work behaviour as due to the consumption of alcohol vs. cannabis is impossible and must wait on an experimental study of the behaviour of alcoholics under economic conditions which match those reported for the cannabis studies.

CONCLUSIONS

In the examples cited above we have attempted to illustrate the usefulness of the economist's conceptual framework in analyzing individual behaviour in token systems. This conceptual framework, which views behaviour in an economic system as an interconnected whole in which change in one part of the system is likely to affect behaviour in many other parts, while recognized by psychologists and psychiatrists, is not a central element of their framework of analysis as it is for the economist. Recognition of the importance of these interdependencies indicates the need to more fully report both the individual data and the conditions under which token economy experiments are conducted. Since relatively small differences in economic structures have been shown to result in substantial differences in the behaviour being studied, the economic structure must be fully reported in order to evaluate the results of an individual experiment as well as to compare results from different experiments.

It should be noted that our application of economic concepts and relations to the behavioural phenomena discussed here does not imply that extensions of operant or other behavioural theories are incapable of accounting for these same phenomena. Rather, economic concepts and relationships highlight aspects of behaviour which operant and other behavioural theories have, to date, not dealt with. New developments in operant and economic theory may change this situation.

In outlining and illustrating the conceptual framework employed by economists in studying behaviour in controlled economic systems we have stated the central concepts to be used in developing a theory of economic behaviour. Planned environments have an important role to play in developing such a theory. They provide unique opportunities for the controlled observation and experimental analysis of economic behaviour which are either unavailable or available only at great expense in national economic systems. The paucity of empirical observations of individual economic behaviour from national economic systems to use in building such a theory is most clearly illustrated by the fact that the observations used above in demonstrating the empirical relevance of the conceptual framework offered were all taken from token economy research. Indeed, as stated in the Introduction, the principal attraction of planned environments to empirical economists is as laboratories for the experimental analysis of economic behaviour. Cooperative research between economists and psychologists and psychiatrists is essential to realization of this goal.

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[9] Personal correspondence with Mendelson.

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Methodological and Conceptual Issues in Testing Economic Theory of Consumer Demand in a Token Economy

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Edwin B. Fisher, Jr., Robert L. Basmann and Leonard Krasner

Winkler and Krasner (1971) and Kagel and Winkler (1972) have called for the development of experimental analyses of economic behaviour. They have mapped out areas of research in which the two fields of economics and applied behaviour analysis can merge in such a way that both fields mutually benefit from each other.

The impetus for this merger can be traced to Skinner's earlier suggestions in *Science and Human Behavior* to subject economic phenomena to experimental analyses (Skinner, 1953). It has taken 20 years for these suggestions to be put into practice. Token economies, which are themselves an historical product of Skinner's call to move operant analyses into the then new areas of behavioural therapy, have now been shown to operate according to economic principles (Winkler, 1971). The initial research on the economics of token economies has tended to concentrate on understanding behavioural processes in therapeutic economies (Winkler, 1973) and, as such, has remained with the historical tradition of operant applications in clinical settings.

The stress in this paper will not be on therapeutic processes but on the development of experimental analyses of economic behaviour *per se*. The more appropriate historical antecedents of this paper are not those of token economy research, but the earlier suggestions that economics is an important area of human behaviour that can and should be experimentally analysed in its own right. Although the research to be reported here does have clinical implications, the principles under investigation were chosen as worthy of study primarily because of their significance in understanding the economic behaviour in which we all engage. While we work in thera-

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peutic token economies, we must ensure our research on economic behaviour does have a dual rationale: one "pure economic" and the other applied, but this is a function of the use of therapeutic economies as research sites, and not necessarily of behavioural economics itself. Economic behaviour is in itself sufficiently important an area of behaviour for research that it need not be justified on other grounds.

Despite the close links between behavioural economics, theoretical economics and applied behaviour analysis, considerable difficulties arise in empirically investigating those ties. The conceptual and methodological orientations of economics and applied behaviour analysis are extremely different. It is important that these differences be clearly understood, so that concepts are correctly used by all concerned and methods are appropriate to the new questions being asked. Concepts and methods new to one or both fields will be refined only through joint research and then only by successive approximations. Without such joint research, psychologists are likely to develop new languages involving problems economists have dealt with and can correct but which psychologists may not see (*cf.* Kagel *et al.*, this volume) or are likely to blithly assume, as a matter of faith, that all economics is reducible to known operant principles. A theme of this paper is that study of molar levels of behaviour can guide more micro-level analyses and vice versa.

This paper aims to illustrate some of the methodological and conceptual issues that have arisen out of research into the economic theory of consumer demand. The study illustrates how applied behaviour analysis and economics can be interrelated in the study of economic behaviour for its own sake, thereby improving methods in both areas, exchanging concepts to deal with common problems, and linking together economic behaviour in national economies, token economies and operant laboratories.

Behavioural economics has, so far, been concerned with experimental investigations of economic theory in environments designed on the basis of operant research and investigations of operant environments using economic concepts. The first study carried out by our team of economists and psychologists in a token economy for chronic patients at Central Islip State Hospital (Battalio, Kagel, Winkler, *et al.*, 1972) illustrates the special problems involved in this type of research.

Much of econometric theory is based on *axioms*. For example, in order to explain the relation between changes in income and changes in expenditure, Keynes (1938, p. 96) refers to a "fundamental psychological law, upon which we are entitled to depend with great confidence both *a priori* from our detailed knowledge of human nature and from the detailed facts of experience." Samuelson (1948, p. 277) refers to "assumptions" made, "on a basis of *a priori*, intuitive empirical experience." To an economist, such statements may be axioms upon which theories are based, but to a psychologist they are assertions about human behaviour which can and should be subjected to experimental investigation. If conditions can be found under which the behavioural principle defined by the axiom does not hold, then the theory cannot be validly applied under those conditions.

Not all econometric theory has made clear the nature of its axiomatic assumptions. However, consumer demand theories do base themselves on a clear assumption or condition, and this condition can be formally stated[2]. Crudely put, a necessary

[2] The basic assumption under test is common to the two major theories of consumer demand: revealed preference theory and the Slutsky-Hicks theory.

condition for consumer demand theory is that, over a series of budget sets, if a consumer chooses a bundle of goods A over a bundle of goods B then he will not choose B over A under conditions where a choice of A over B is possible. This does not mean A will always be chosen over B since, with price changes, B might be chosen over A. Only under certain specifiable conditions will a choice of B over A indicate inconsistency. (For a formal statement of this condition, see Battalio, Kagel, Winkler *et al.*, 1973.) Once the assumption is specified, and formally stated, it needs to be restated such that it can be subjected to empirical test.

This necessary condition for consumer demand theories has been investigated previously by economists (Koo, 1963; Mossin, 1972; Koo and Hassenkamp, 1972). Koo (1963) found fewer than 15 per cent of the families he studied purchased in a fashion consistent with the basic axiom of consumer demand theories and Mossin (1972) reports no instances where families satisfied the axiom. To an empirically oriented social scientist, such discoveries, if methodologically sound, would do irreparable damage to a theory. Apparently not so in economics. Koo (1963) in fact, sums up his study by stating:

> In conclusion it is hoped that this exploratory study has achieved its limited objectives: to examine how testable the theory is in principle, to explore the possibility of using denominational conditions, and to demonstrate what a computer can do in the study of revealed preference. (p. 663)

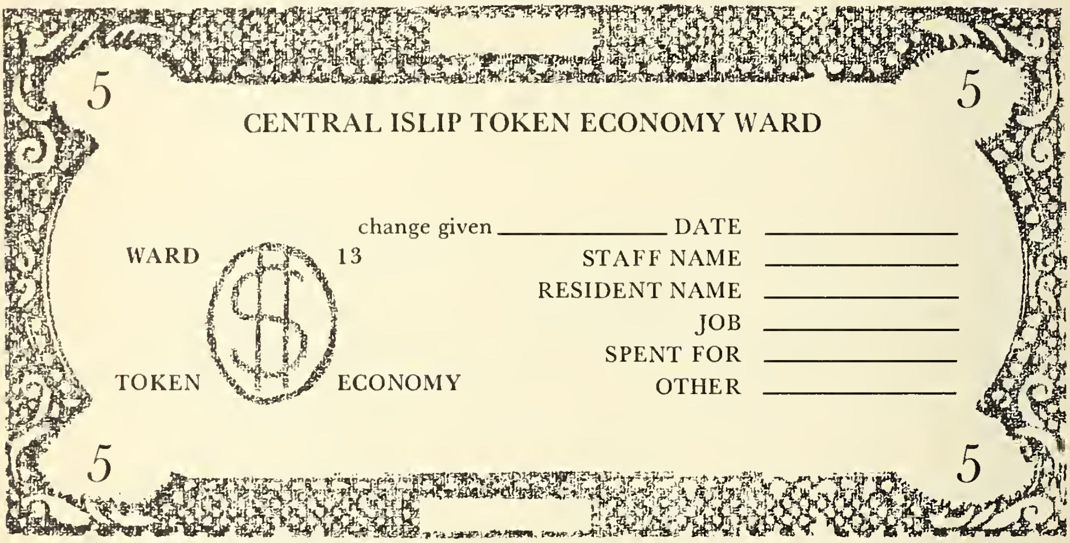
A major aim of behavioural economics research is to make empirical data more pertinent to the evaluation of economic theory, an aim that is anachronistic in most of psychology but not so in econometric theory.

It is possible, however, to show that previous studies in the national economy of the basic axiom of consumer theory are not satisfactory tests of that theory. The problem lies in the special methodological demands built into the question being asked. A feature of the axiom or basic condition in question is that price changes only result in opportunities to put the axiom to test when the budget constraints allow both a choice of A over B and B over A given the two different sets of prices. Two interacting factors determine the ability of a study to put the axiom to test, *viz.* the amount of price change occurring during the study and the degree of observation error in recording consumption. The bigger the price variations produced or observed, the higher will be the proportion of price sets which allow a test of the axiom. Observational error will clearly also cut into this proportion, so that the smaller the price variations, the smaller must be the error, simply to allow a choice situation where the axiom can be put to test. The previous national economy research by Koo, Mossin, and Koo and Hassenkamp, did not have prices under control and so had to make observations in the face of small, "naturally occurring" price variations, thereby severely delimiting the opportunities to test the theory. If observational error were well controlled, however, the studies might still stand, but in none of the three studies was any observational error term specified or even mentioned.

A test of the basic axiom of consumer demand theories is a particularly appropriate topic for investigation in a token economy. In a token economy, prices are under the investigators' control and can be shifted by large amounts. Also, in a token economy, systems can be developed in which it is possible to define and delimit observational error.

However, the normal criteria for assessing the adequacy of behavioural observations in token economy work are not sufficient for this type of work. For each unit of data in the Dobell analysis for each individual, there should be a known range of error. Inter observer agreement can only provide estimates of error from a sample of observations of consumer behaviour and even 90 per cent agreement from such samples may be insufficient for this type of study.

We therefore had to develop a method for assessing measurement error which would give us a defined error range for each unit of analysis, and a system to keep that range extremely narrow. Accordingly, for each individual and for each purchasing occasion, two sets of records were made which, if they were carried out accurately, would match each other. The first measure was based on trained observer records of each item purchased (exchange point record). The second measure was based on tokens handed in (token record). See Figure 1



5 5

CENTRAL ISLIP TOKEN ECONOMY WARD

change given ____________ DATE ____________

WARD 13

STAFF NAME ____________

RESIDENT NAME ____________

JOB ____________

SPENT FOR ____________

TOKEN ECONOMY

OTHER ____________

5 5

Figure 1 *Example of a token and record*

Tokens were paper notes and on each token, staff recorded the date the token was earned, the name of the member of staff who gave the token, what the token was given for, and once spent, the type of good on which the token was spent. Spent tokens were sorted according to date spent, were stored and could not be used again. For every purchasing opportunity, it was therefore possible to compare exchange point and token records. If there was a discrepancy, this could be used to define a range of error for that purchasing occasion for that individual. This system did not allow a determination of the item on which discrepancy occurred, hence any distribution of error over items that was consistent with the discrepancy in totals was regarded as possible. Correlations between exchange point and token records for each week of the 7 weeks of this study ranged from 0.84 to 0.99 for store items.

Eighty per cent of all purchasing occasions over all individuals for all weeks showed 10 per cent of error or less.

A more sophisticated system was developed for a further series of studies on behavioural economics in a token economy for stutterers at Prince Henry Hospital, Sydney, Australia. This programme involved groups of 6 stutterers moving through a graded training speech hierarchy with correct speech being rewarded with individually coloured tokens. The stutterers resided in the hospital while they completed the programme. Speech was rated for training sessions and assignments using a technique that produced high inter-rater agreement (Ingham, Andrews and Winkler, 1972).

The recording system for these studies again relied on internal consistency checks. All stutterers recorded their own earning, spending (in coded categories) and savings stock. These records had to be complete before tokens could be earned at rating sessions. These records were checked against the following:

(1) *Money control* – the number of tokens available for earning in each colour was recorded at the beginning and end of each day, giving the number of tokens earned by each individual each day. This check is similar to one used in the Central Islip record system.

(2) *Token Boxes* – tokens handed in for meals, cold drinks, hot drinks, goods on a display counter and penalties, had to be placed in one of the 5 boxes labelled meals, cold drinks, etc. Tokens in each of these boxes were cleared at the end of each day and records for each individual's expenditure made from them.

(3) *Inventory control* – all goods sold except meals were recorded by inventory checks made at the end of each day. Hot drinks were automatically dispensed and were recorded by cumulative counters on the different items. Meals were purchased at the hospital cafeteria and cash register receipts were retained as a record of goods purchased. This record system allowed for 3 internal consistency checks for income measures and 3 internal consistency checks for expenditure measures. If there were discrepancies in any of these checks, the relevant person was called in and required to stay back at the end of the day until his books balanced. The multiple records and individualized tokens allowed the source of any errors to be tracked down quickly.

The daily balancing of the books not only provided daily interlocking measures on all behaviours, for each individual, but checked the possibility of staff errors in regulating both the earning and spending of tokens.

During the 3 weeks of the first study using this system, on only 2 occasions could the books not be completely balanced for each of the 6 stutterers, *i.e.*, no explanation could be found for the discrepancy. These discrepancies amounted to 23 tokens in 3 weeks, or 23 token errors out of approximately 138,000 token transactions during that period (Winkler, Kagel and Battalio, 1973).

It should be clear that testing economic theories in token economies requires criteria for evaluating data that are different from those normally used in operant token economy research. For each individual, for each day of a study, all spending and earning need to be broken down into detailed categories and recorded. For each set of observations, a system of recording error of observation must be implemented, and, depending on the question at issue, that error may have to be kept to a lower level than that usually accepted in operant research.

The next step in testing the major assumption of consumer demand theory was to specify an experimental design in which prices were systematically varied. No previous studies of consumer demand theory have had an economy in which they could control the amount and timing of price changes in an ongoing economy. As such, there were no guidelines as to what type of experimental design would be most appropriate. In a sense, this did not matter, since the assumption under test was stated as a universal. But it was to be expected that, empirically, different designs would have different behavioural effects. A second problem was that manipulation of prices should not interfere with the ward's therapeutic activities. So rather than shift all prices up or down simultaneously, we divided goods into three groups. One group had constant prices throughout (e.g., meals), while the other two were simultaneously halved or doubled, thereby keeping the overall economy generally functioning on an even keel[3]. Operant methodology, being based on research with single subjects, was particularly suitable for this study, since the Dobell analysis is written for individuals consuming under different prices over time, thereby requiring frequency data, as in operant work. Each individual is a potential disconfirmer and *must* be studied separately. The design used was based on the ABABA designs used in experimental analysis of behaviour.

TABLE I

EXCHANGE RATES OF COMMODITIES RELATIVE TO PRE-EXPERIMENTAL CONDITIONS

Week	Group 1	Group 2	Group 3
1	same	same	same
2	half[1]	double	same
3	same	same	same
4	double	half[2]	same
5	double	half	same
6	same	same	same
7	same	same	same

[1] Since there was no half token note in the currency and the pre-experimental exchange rate for room rent was 7 tokens, the rate was changed to 4 tokens.

[2] Pre-experimental prices of penny candy, cookies and milk were 1 token each. When prices of items in Group 2 were halved, patients had the option of buying two of one item for 1 token or of buying one of each of two of these items for 1 token.

Analysis of the frequency data on consumption for groups 1, 2, and 3 showed that price controlled consumption and that using exchange point records as the measure of consumption, 19 out of 38 people consumed in a fashion consistent with consumer theory. Since disconfirmers are of most interest, the error terms were examined (for the remaining 19) to see if error might account for the inconsistencies. Using the previously defined range of error, 17 of the 19 could be rendered consistent by considering measurement error, *i.e.*, a score between exchange point and token store records for the unit in question (a week) could render the consumer consistent.

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[3] The ability to make price variations of this size produced situations where more than 80 percent of total expenditure planes intersected when prices differed.

This apparently large error reflects the special nature of the question being asked. For 10 of the 17 rendered consistent by considering error, errors of 3 tokens or less in measuring expenditures, which is less than 10 per cent of average per capita expenditure during the test period, were responsible for our inability to distinguish between error and inconsistency. For 5 of these 10, an error of 1 token would have been enough. Correlations between measurements of 0.88 to 0.99, obtained over subjects within weeks, may be acceptable in behaviour modification research but are clearly insufficient for the demands of new questions raised in testing consumer theory. The observational system developed at Prince Henry therefore becomes especially important for further investigations of consumer demand theory. The fact that previous studies by economists of consumer demand theory using the analysis employed here make no mention at all of error, is perhaps an indicator of the lack of empirical emphasis in economics.

Since the two people who still remained inconsistent even after error was considered were of special interest, they were subject to more detailed study[4]. The results of this study indicate how operant research can be used to understand economic phenomena. Ayllon and Azrin (1968) in their search for ways to stimulate purchasing in therapeutic token economies showed that free samples of consumer goods, or reinforcer sampling, was able to increase consumption of the sampled good that continued after the free samples were no longer available. This "operant" research led us to explore the possibility that price changes can shift consumption to goods not previously sampled, such that once they are sampled, they will continue to be purchased after the price changes have been terminated. Free samples may therefore be seen as the final point of a continuum along which the absolute or relative price of an item is reduced. We were able to show (through Ayllon and Azrin's research) that reinforcer sampling could shift consumption after the reduced (zero) price had terminated, and were able to show a process similar to reinforcer sampling could have occurred in the Central Islip study (Battalio, Kagel, Winkler *et al.*, 1973). Operant research has, therefore, now defined a problem for economic theory which can be subjected to an experimental analysis, such that it will be possible to specify conditions which can reliably produce consumer behaviour that is inconsistent with the economic theory of consumer demand.

Experimental analysis of this question is now under way, not in a token economy, but in a Skinner box. Behaviour modification developed as the extension of basic operant principles established in animal research to the understanding and modification of human social problems. The ability of applied behaviour analysis to operate successfully in human social contexts indicates that animal research is one good source through which human behaviour can be understood. Economic principles, as we have seen, can be stated in very general and basic terms, as behavioural principles. It would seem that the very same arguments in behaviour modification which stress operant principles established in animal research can be used to call for animal research into economic behaviour.

The assumptions of consumer demand theory are essentially assumptions about choice behaviour in the face of budget constraints, prices and commodities. Choice behaviour with animals can be defined as responses on keys, where one key is followed, for example, by food, and another by water. Prices can be defined as the number of key presses required to produce a unit of food or water. Budgets can be defined as the number of responses available to the subject in a given time period. The questions asked of behaviour in this situation can be derived from economic theory of consumer demand or from token economy research, such as that just described. In this way, behavioural economics in animal research, token economy research, and research in national economies can be closely integrated, such that operant and economic theory are blended, with the flow of ideas and methods going from applied to basic research, and from basic to applied research. Research with animals on consumer demand theory is now under way (Rachlin, personal communication 1972; Kagel, personal communication 1973), thereby linking up with token economy study described here and the national economy studies of Koo (1963), Mossin (1972), and others.

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[4] For the first of these two, error was 0 in the 2 weeks of inconsistency and for the second, error was 0 and ½ token in the 2 weeks inconsistency occurred.

Although we have seen how operant concepts and methods can be involved in handling the testing of economic hypotheses, it might be felt that it is economics that will benefit from this research more than applied behaviour analysis. The psychologist might say to himself "what's in it for me?" Subsequent articles in this book will show the clinical implications of this work for therapeutic token economies, but clinical emphases can draw attention away from the simple proposition that economic behaviour is at least as important an aspect of behaviour as (perhaps more important than) other areas of behaviour we normally study as psychologists. It is academic disciplines that have forced behaviour into "economic" and "non-economic" divisions and it is this strange separation by academia that produces questions of the value of behavioural economics for applied behaviour analysis.

A brief example may suffice to illustrate the value of economic concepts in areas of behavioural economics more familiar to applied behavioural analysis. The previously mentioned research at Central Islip allowed not only a study of consumer theory but of the effect of price on income-earning behaviour. We began by regarding price (exchange rate) as the independent variable, since this is what we manipulated, and therefore related price changes directly to income-earning behaviour. But it was not until we recognized that the same price change will affect individuals differently depending on the degree to which they bought, during baseline, the items whose price was altered, that we realized the appropriate independent variable was not price but individual price indexes, calculated according to standard economic procedures. With individualized price indexes, we were able to show that a price change which increased real wages (wages divided by the price index) improved income earning behaviour for low earners and produced a drop in income earning behaviour for those with high incomes. Perhaps without economists working on the data, a similar analysis and procedure might have eventually been used by operant researchers, but it is likely the process would have been slower.

Future Directions for Behavioural Economics

Behavioural economics has grown out of research in token economies established for therapeutic purposes. As such, there are inevitable limits placed on economics research by the need to maintain the clinical effectiveness of the economy. Also, while there is as yet no evidence that the economic behaviour of psychiatric patients or stutterers is different from the economic behaviour of non-clinical populations, it is likely that behavioural economics will not be accepted as easily if it is limited to working with clinical populations. Behavioural economics using therapeutic economies is further constrained by the often unpredictable demands placed on the research by the institution in which the token economy is situated. For example, in the Central Islip study just mentioned, leave from wards was abruptly restricted by the hospital administration following a complaint about someone on leave from another ward, thereby upsetting the availability of consumption opportunities for certain persons in the ward. Finally, it is important that behavioural economics be separated from clinical work and be seen as a study of economic behaviour which is important in its own right. This will not prevent behavioural economics from contributing to the planning of therapeutic token economies since behavioural economics research under more controlled conditions can provide more and more soundly based planning ideas for therapeutic systems.

Planned environments in which a micro-economy is established solely for behavioural economics research therefore appear to be a logical development for this new field. The micro-economies used by Miles *et al.* (1974), in which non-clinical groups of volunteers live for extended periods, illustrate the feasibility of this concept. Planned environments incorporating simplified economic systems and used solely for research have also been established by Findley (1966), and by psychologists interested in developing and studying alternative life styles (Mertens, 1971). Similar planned environments not incorporating economic systems have also been successfully established.

Planned environments for research in behavioural economics can provide an opportunity to work with non-clinical populations and provide the control needed for satisfactory research. However, any move to develop planned environments for research purposes must be made with extreme caution. Social science research, if accepted by those who have power, can shift the world we live in so that it becomes similar to the situations in which that social science research was originally conducted. Such a process is inevitable, since the concepts and methods of social science work most effectively under the conditions in which they were first developed. This process would be especially dangerous if it were to follow from planned environment research. Findley (1966), in summarizing his early work with planned environments, exemplifies the problem clearly:

> . . .the usefulness of such new knowledge, however, would not be a direct application to the natural world as we know it, since the relationships would apply only under certain stated conditions. What could be expected, on the other hand, is a partial restructuring of the natural world to accommodate the new techniques. (p. 847)

The legal and ethical implications of planned environment research also need to be thoroughly explored.

Research in planned environments can draw together diverse areas of human behaviour, as this symposium has indicated. This applies not only to links between operant and economic behaviour, but between economics and sociology. It has been argued extensively by social theorists that economic systems both reflect and sustain fundamental social beliefs. For example, Fromm (1947) has argued that a capitalist economic system reflects a belief in individualistic competitiveness and produces what he has called "the marketing personality". Bronfenbrenner (1970) has suggested how Russian Marxist and American capitalist systems produce different interpersonal relationships in educational environments. Economists, working in the area of comparative economics, have also studied different macro-economic systems and their effects on both economic and social behaviour (Grossman, 1967). But these studies have been primarily observational and therefore unable to directly link different types of economic systems with different types of social and economic behaviour. It is only through experimental analyses that such direct links can be asserted on an empirically sound basis.

Economic systems in planned environments provide a hitherto unavailable opportunity to experimentally analyse hypotheses drawn from comparative economics and sociology. Such work has, perhaps unwittingly, already begun. Hamblin *et al.* (1972), and others have systematically compared various types of group reinforcement schedules to individual payment systems, looking at both income earning behaviour and interpersonal interactions as a function of these different types of economic systems. Phillips, Bailey and Wolf (1969) have compared worker operated payment systems to staff (employer) operated payment system. Winkler and Krasner (1971) have reported the use of profit sharing systems in token economies.

National economic systems studies in comparative economics and sociology can be broken down into basic structures which can be experimentally analysed in planned environments, token economies and operant laboratories. These experimental analyses, guided by macro-economics and sociology, can substantially enrich basic research as well as show how global analyses and experimental analyses can profitably interact.

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Toward a Behavioural Ecosystems Technology

Raymond G. Studer[1]

Success in applying operant principles, that is, the development of a behavioural technology for dealing with behaviour problems in limited, specialized and somewhat controlled settings has understandably generated a measure of optimism. More ambitious efforts are now under way with a view toward more comprehensive application of this technology in larger, "natural" settings, *i.e.*, at the community level or possibly on the urban scale (e.g., Everett, 1974). Behavioural technologists will, however, continue to encounter new difficulties as they attempt to extrapolate these techniques to more complex settings. The design and management of larger environmental-behavioural systems of interest will clearly require more elaborate conceptual and methodological resources. The rather pretentious term *behavioural ecosystems technology* has been adopted to connote this elaborated approach to behaviour analysis and change required for more complex problem situations.

There is an intrinsic relationship between size and structure. This is true in both biological and social systems (Alonso, 1963). Contemporary urban settings are quite unmanageable simply because they are the most complex social/economic/physical systems man has encountered. Designers and planners have for years attempted to address the complexities of organizing and managing these larger human settings. That their success has been highly limited has been well-documented; however, research growing out of these planning and design efforts can, it is claimed, make a significant contribution to systematic behaviour change strategies in more complex settings. Specifically, formal design methods and/or decision-making strategies much discussed in the design and planning literature provide relevant tools for the applica-

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tion of behavioural technology on a larger, more comprehensive scale (Moore, 1970; Cantanese and Steiss, 1970; Lee, 1973). The difficulty has been that designers and planners have dealt with units of analysis — have conceptualized variables in their decision-making processes — in dimensions which are difficult to assess empirically and link systematically to the human systems accommodated, e.g., "buildings", "physical performance standards", "human wants and needs", "land use".

Virtually all communities face critical dysfunctions which reduce their viability. The manner in which such problems as transportation, crime, education, health care, pollution, and scarce natural resources are defined obviously makes all the difference in the way we go about solving them. If the problem is seen as one of inadequate physical technology (the engineer's view), more of the same is provided (often without regard to ecological cost). If a problem is seen as, for example, aggregate economic or political dysfunction, the appropriate discipline or profession comes to bear as the primary resource. Human problems do not as a rule fall into such neat categories. It is generally agreed that a transdisciplinary approach is necessary in organizing the environment in response to man's multifaceted problems. Some elements of such an approach are noted below.

Designed environments, as solutions to human problems, are by definition *artificial* (Simon, 1969; Studer, 1971); that is, they are designed in response to (normative) goals and realized not by analysis but synthesis. Natural systems are by contrast not so organized. A human problem arises when there is a disparity between people's intentions and their accomplishments — between things as they are and as they *ought* to be. To reduce this disparity requires a change in behaviour potential. The designed environment, an organized system of energy-matter elements, is one which is interposed between human behavioural goals and antithetical impingements from the general environment. The designed environment, like the human environment, generally can be partitioned into economic, political, social, physical, or *n* components. The design task is the coherent organization of these various classes of environmental elements in such a way that an appropriate behavioural texture emerges.

A behaviour-contingent approach to environmental design (Studer, 1970, 1971) is predicated on the reality that designed environments must be evaluated in terms of empirically accessible units of behaviour. Environmental problems must, therefore, be formulated in the same dimensions, *i.e.*, behaviour is generally the class of dependent variables in analysis but it is the class of *independent* variables for design synthesis.

The process of environmental design and management is directed toward the realization of an appropriate state of *congruence* between the environmental structures and the behavioural structures (Michelson, 1970; Wicker, 1972). Clearly neither the behavioural nor the environmental systems must form nor conform to the other. The task is to realize — to design and implement — an environment-behaviour *ensemble* (Alexander, 1964) which fulfills the goals of the setting under analysis. The decision to intervene is occasioned by documentation that either certain behaviours *are* occurring which are antithetical to the goals in effect, and/or certain behaviours are *not* occurring which are required by those goals.

Environmental design and management, then, is an enterprise committed to behaviour change and maintenance. The principles and techniques of an operant-based behavioural technology are thus central to the processes involved in the design and management of human settings. This is a fact which has gone virtually unrecognized in the training of engineering, design and planning professionals, shapers of the physical environment.

Behaviour modification via operant principles, *i.e.*, the arrangement of contingencies of reinforcement, involves two interdependent processes (Homme, 1968): 1) *contingency management* – arrangement of the environment such that the probabilities of reinforcing consequences increase as a function of appropriate behaviours, and 2) *stimulus control* – the iterative reinforcement of particular behaviours in the presence of particular stimuli (a technique of unrealized potential in the design of physical systems). Behaviour modification utilizing both contingency management and/or acquisition of stimulus control involves the following sequential operations:

1) Empirical analysis of the environmental-behavioural baseline
2) Definition of new behavioural objectives
3) Manipulation of appropriate environmental contingencies
4) Assessment of the altered behavioural states
5) Iteration of 3 and 4

Systematic behaviour change is not accomplished in an "all or none" fashion, but involves a series of intermediate states, *i.e.*, successive approximation toward defined objectives. This process – the need for a dynamic presentation of environmental events – identifies an interesting dilemma for designers and managers of the physical environment (which has heretofore been conceptualized as essentially static). High performance physical systems to facilitate the dynamics of human learning would seem to require modification along some sort of continuum – a technological challenge of immense, but not impossible, proportions.

In any event designers of the human environment control either directly (e.g., the physical environment) or indirectly (e.g., the social environment) the configuration of a number of variables (environmental contingencies) which maintain present forms and could be organized to effect new forms of behaviour. Because neither the behaviour-contingent approach noted above nor the scientific principles of behaviour change are generally implemented in extant planning and design processes,[2] the organization of contingencies in new designed environments exerts either a random or unintended influence, or little influence on the desired state of affairs.

Many researchers, while acknowledging the effectiveness of behaviour modification techniques, are notably unenthusiastic with regard to expanded application. Their objections are technical (Willems, 1973). The argument is that this technology, as well as the laboratory science upon which it is based, has typically focused upon limited repertoires of single organisms in controlled environments. There is no denying that application to larger interpersonal human settings presents a new set of problems.

Both convincing empirical evidence and common sense tell us that complex human settings operate within certain (not yet defined) tolerances in terms of the system-wide networks of interdependencies. The introduction of significant changes in particular behaviours can have unexpected side effects on other aspects of this network. At least the burden of proof would seem to lie with the change agent in this regard. It appears that we need additional experimentation in more complex settings but, equally important, we must adopt an *ecological perspective* in dealing with the design and management of more complex, "natural" settings. Experiments in relatively impoverished token economies such as those reported in this volume tend to reinforce this view; that is, system-wide influences appear to operate in ways not altogether predictable through analysis of a particular exchange point.

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[2] It should be parenthetically noted that behavioural technologists have demonstrated little understanding of the more effective decision-making models which have been developed in, e.g., design, planning and management science. The central argument of this discussion is, therefore, that a synthesis of these two domains is needed.

Analogues for developing this ecological perspective can in all probability be found in natural ecosystems, both living and nonliving. These ecosystems exhibit certain well-documented characteristics which can inform our search for appropriate strategies in more comprehensively designing environment-behaviour systems. These natural ecosystems have in common such characteristics as hierarchical levels of complexity and subtle interdependencies amongst both elemental units and subsystems of them. These interactive systems are open and the transfer of energy at the boundaries produces a dynamic adaptation to changing inputs; that is, they exhibit self-regulating behaviour via intra- and inter-system feedback linkages.

For some time researchers have explored the possibilities that human *behavioural ecologies* operate within the same general principles as other ecosystems and have claimed documentation of these (Barker, 1968; Willems and Rauch, 1969; Wicker, 1972; Altman, 1973). Communities of humans have been described in terms of *behaviour settings*, social/environmental units which exhibit sustained, recurring "standing patterns" of behaviour across a number of individuals in a number of situational contexts such as the classroom, the opera, baseball game, corner drugstore. Behaviour settings have been shown to influence roles of participants, relationships amongst behaviours emitted, number of participants, quantity and qualities of behaviours emitted to cite a few examples. A functional (as opposed to a discursive) understanding of these phenomena has not yet emerged, but if predictive models can be developed the implications for environmental-behavioural design and management are quite obvious. An operant paradigm provides a likely resource in moving toward a functional understanding of behaviour setting phenomena (Studer, 1973a). If a functional analysis of behavioural ecologies can be developed we can move toward the *design* of requisite behaviour setting units within sound ecological principles. Within the same principles the application of behavioural technology would facilitate the implementation of new, and the phasing out of undesirable, behaviour system components in response to the changing goals of a community. In short, the argument here is for the development of a more systematic explanation of behavioural ecosystems and for the synthesis of behavioural ecology and behavioural technology.

A general systems perspective is implicit in this more comprehensive approach. The final component of this argument is that a systems-oriented, behaviour-based environmental design and management strategy provides a synthesizing format for applying behavioural ecology and behavioural technology as well as other resources from the behavioural sciences (Studer, 1973b).

Arguments for a more elaborate behaviour-contingent design and management strategy have been developed elsewhere (Studer, 1966, 1970, 1971). A comparison of the elements of this strategy with the generally accepted behaviour modification strategy described above reveals additional operations deemed necessary in the design and management of environment-behaviour systems for larger, more complex settings. The functional elements of this sequential decision-making strategy include briefly:

1. *Empirical observation* of the environment-behaviour system; an inventory of behavioural and environmental elements and subsystems as well as the relationships amongst these, *i.e.*, a behavioural ecosystem baseline analysis.
2. *Modelling* of the environment-behaviour system ensemble as it exists. This model is necessary to make observations of the existing ecosystem tractable.
3. *Behavioural ecosystem design* moves well beyond the indentification of certain "target behaviours" (as is the case in limited behaviour modification programmes) and toward the design of a behavioural network – an overall behavioural texture required to meet the goals of the setting. This behaviour design task involves two operations: a) development of the goal structure of the population and b) operationalization of these goals in empirically accessible units of behaviour. When this requisite behaviour system is compared with the existing one the discrepancy (between ought and is) defines a behaviour modification problem.
4. *A requisite environmental system* must be specified which supports the requisite behavioural system with the highest probability; essentially a prediction that, given the organization of a particular system of environmental stimuli, the requisite behaviours will emerge.
5. *Simulation* of proposed environment-behaviour ensemble in its functioning state under the influence of external constraints. Reliable (predictive) models of complex environment-behaviour systems are generally unavailable. Moreover, there are no algorithms for transferring such models to real world settings. Iterative simulation experiments provide the most effective means available for systematically pretesting, refining and predicting the performance of such complex systems prior to implementation. The risks, both human and material, of implementing untested complex systems are, on the other hand, considerable.
6. *Implementation* of the environment-behaviour system follows refinement and pretesting via simulation experiments. Only when implemented can the performance of this system be verified.
7. *Testing* of the implemented system involves comparing the resultant behavioural ecosystem with the requisite one. Even with careful specification and pretesting (via simulation) of the ensemble the complexity of variables renders the attainment of initial congruence between requisite behaviours and the designed environment highly problematic.

What seems mandatory here is that environmental designers/managers adopt a dynamic (iterative) experimental approach (*i.e.*, successive approximation) to realizing appropriate ensembles. Such an approach is necessary for reasons which go beyond our inability to make predictions regarding the performance of complex ensembles. Changing goals, behavioural propensities (due to learning) and changes in exogenous constraints on the ensemble (e.g., economic, physical, technological, political) produce the expected dynamics of living systems. A controlled approach to the future which acknowledges this human dynamic requires the decision-making instrumentality noted above which operates on a continuous basis, the software of guided social change.

This behaviour modification strategy, an elaboration of that noted previously, addresses the problems of moving up the scale of complexity – accommodating a more comprehensive set of behaviours. Systematic behavioural design is necessary in order to explicate and support the ecological nature of larger populations. Model building is necessary to make complex systems tractable. Simulation experiments are necessary because we cannot make reliable predictions analytically. Finally, a formal decision-making instrumentality — a dynamic design and management format — is necessary to support the complex open-system characteristics of human settings. Such an instrument is implicit in the realization of a behavioural ecosystem technology.

How could such a technology affect communities as we know them? We haven't really come very far in dealing with problems associated with an urbanized, technologically sophisticated culture. Indeed urban problems appear to be generating at a faster rate than solutions. If one thing is pervasively understood, it is that such problem areas as economic maintenance, pollution, consumption of scarce resources, health maintenance, transportation, education, and crime, ultimately involve human behaviour which must be changed if the problems are to be corrected. This behaviour is under the control of contingencies operating in the various environments, operating on individuals and aggregates of them. Moreover, each of these problem areas involves systems with their own technical demands which must somehow interface with the human behaviours associated with them. The behaviour-contingent organization of these systems along with attention to intersystem interactions will, no doubt, yield quite different environmental taxonomies than now exist.

In the dysfunctional areas of pollution, solid waste management, and overconsumption (or destruction) of scarce resources, for example, we can recognize that the present state of affairs is maintained via the behaviours of individuals in pursuit of goals inimical to the viability of these critical support systems. These incompatible behaviours are supported by the particular system of contigencies operating in the various environments impinging. Commoner (1971) and other ecologists have documented certain of these. People are able to emit such self-destructive behaviours as those associated with, say pollution, because the environment has evolved in such a way that consequences of those behaviours are generally unavailable to the actor at the time they are emitted. Rather these consequences are dampened, delayed, intensified and (most importantly) aggregated to a point where they become unexpectedly critical to biological survival.

Campaigns to change people's attitudes toward critical problems or to engender an environmental or social ethic have been notably unsuccessful because consequences antithetical to this objective are too powerful. Research from the behavioural laboratory has provided convincing evidence that behaviour is controlled by the spatial-temporal relationship between behaviour and its consequences. If the consequences of behaviour in the above domains are not so arranged, costly aggregated effects result. An appropriate strategy is one which disaggregates these consequences (of pollution behaviour for example) and brings these into spatial-temporal relationship with the relevant behaviour. The issue or problem domain is one of arranging the man-made (or interfacing with the natural) ecosystem in such a way that the human behavioural component supports its maintenance (Studer, 1970).

Reorganization of environmental contingencies does not necessarily involve inputs of new resources; indeed just the opposite can be true. The objective is more often to identify extant subsystems or processes which can be brought into a new relationship. In some recent research to reduce automobile use and increase bus ridership (Everett, 1974), a token system was set up. Various schedules were implemented to find limits in thinning schedules of reinforcement. In the process, it was found that the additional expense of delivering reinforcement (over normal operating cost) could be borne by local merchants who trade merchandise for the tokens. Their reinforcement was the efficient acquisition of new customers, a more effective means than routine advertising, and acknowledgement of their contribution to a better environment.

If it is found that introducing food into a starving country produces an exponential increase in birth rate, thereby increasing the requirement for greater levels of food (a positive feedback system), we must begin to look for a rearrangement of environmental contingencies where food acquisition is somehow contingent on behaviours which reduce the birth rate. To reduce the pollution of a river by certain manufacturers it has been proposed that the water intakes of these plants be located *below* (down river from) their discharge points.

The principle here is that from a systems ecological perspective the appropriate contingencies of reinforcement can be realized through the juxtaposition of processes which positively affect each of them, that is, the potential "energy" of the system is made effective in moving toward certain behavioural goals. This kind of designed interdependence moves toward the status of *self-regulation*, one of the important characteristics of viable ecosystems. A behaviour-contingent approach leads to examination of the behavioural dimensions of such previously disjunctive systems as education, health delivery, the administration of justice, and recreation. This may reveal potentially interdependent components which when appropriately reorganized may yield entirely new environmental taxonomies which can maintain behavioural ecosystems without coercion and/or prohibitive material or human costs. It is this kind of fundamental reorientation of design processes which is needed to reverse dysfunctional tendencies in urban settings.

Current research in the experimental analysis of bounded and partially bounded interpersonal settings, e.g., token economies (Winkler, 1974; Battalio *et al.*, 1974) or microeconomies (Miles *et al.*, 1974; Battalio *et al.*, 1974), identifies the appropriate strategy for testing the application of behavioural technology on a larger scale. These limited experimental settings have produced convincing evidence that the economic environment does approximate that predicted by current economic theory. A similar experimental analysis of contingencies operating in other environments, e.g., political, social, physical, is needed as well. Moreover, we need a clearer understanding of the interdependencies amongst these environments within a behavioural ecosystems perspective. What all of this comes down to is an argument for the expansion of the research in behavioural economics, in the form of larger experimental settings. This is hardly a novel suggestion; Skinner and many others have argued for experimental communities for years. Research such as that reported in this volume, however, indicates that the conceptual and technical groundwork has now been laid to move on to more complex experimental settings. Indeed there appears to be no other way to get on with the elaboration of this important area of applied knowledge.

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The Microcosm of the Mental Hospital

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I was born and raised in what Raymond Studer has called "one of the discrete bureaucracies" then commonly referred to as a lunatic asylum: the only propositus of a staff-nurse and a Kraepelinian psychiatrist who kept the brains of some of his former patients and my acquaintances in a cupboard next to my bedroom. Our house was on the hospital grounds attached to the main building by a conservatory or greenhouse. At about the age of five, I looked through the keyhole of the locked greenhouse door that led to the long corridors of the hospital beyond and through it I saw an eye that looked back at me: a first appreciation of the controlled environment. At a later date I found a key to that door beneath a pot in which grew an aspidistra. Having discovered the back wards off the corridors and having no siblings, I found playmates there amongst both staff and inmates, two of the latter being my special attendants or keepers. Consequently I have always felt at home in mental hospitals and by extension in many other institutional environments towards which I may have developed a proprietary interest. I began to appreciate the snug, overheated seclusiveness of the nurses' staffroom or the porters' lodge with their files, ledgers and rows of heavy keys, charged with the atmosphere of petty authority and calculated obsequiousness to be found in prisons, asylums, workhouses; but also in the services and even schools, or wherever hierarchical structure divides the controlled and the controllers. But to me as a child this controlled environment with its spacious grounds, ritualistic staff, and sometimes eccentric inmates was a great park, garden, or friendly zoo, and when I left it to enter the feral society of a boarding school I felt as if I had been ejected from paradise. Times and attitudes have changed and I hope that I have changed with them and am able to see these institutions more objectively. I find some consolation in an observation of Erving Goffman that the "children of resident doctors were the only non-patient category I found that did not evince obvious caste distance from patients; why I do not know." (Goffman, 1961). I suspect that one of the answers to Goffman's implied query is that the socialization of a child in a mixed environment of inmates and staff provides very broad limits for what Carstairs (1959) has described as the "limits of eccentricity." Eccentric behaviour as opposed to specific rule breaking is well tolerated in a mental hospital and even may be reinforced or encouraged as a characteristic of the patient role, to complement which the hospital exists.

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In the development of European society the mental hospital evolved from the need to confine the violent or 'criminal insane.' The family was the first custodian. In the Tenth Century, a man might be considered as justified in killing if the rules of feud had been observed (the Church might require a penance) but if judged insane the family was required to prevent further bloodshed (Walker, 1968). "For a man to fall out of his senses or wits and it comes to pass that he kills someone let his kinsmen pay for the victim and preserve the slayer against all aught else of that kind." The laws of Henry I (a condensation of pre-Conquest customs) lay down: "Insane persons and evil doers of a like sort should be guarded and treated leniently by their parents." By the Thirteenth Century responsibility had been assumed by the monarch to confine the insane and retain custody of their property, to see that their "lands and tenements are safely kept without waste or destruction; that they and their families live and are maintained from the profits; that what is left from maintaining them is reasonably kept for their use when they are recovered." Insanity is distinguished from idiocy or retardation from birth in which case the King was able to take custody of their lands and their profits "without waste, finding them their necessaries and after their death must return them to their rightful heirs." The estates of idiots continued to be a source of royal income until the end of the Eighteenth Century. When the first prisons were established, usually in fortresses or palaces, they were also used to hold violent lunatics. Private houses and churches were also used and on the continental rivers of Medieval Europe sailed the Narrenschiffen, the 'ships of fools.' As entrepreneurial society grew, private madhouses provided for the wealthy, but these were few. For London, Bethlem was the sole public madhouse from 1377 to 1696 when St. Peter's workhouse for the insane was founded at Bristol. With the Industrial Revolution other hospitals appeared: St. Luke's (London) in 1751, Manchester's Lunatic Hospital in 1763; and York Asylum in 1777.

The discovery of abuses in private madhouses led to the gradual establishment of county asylums, and doctors began to take a specialized interest in the care and treatment of the insane. William Batty, medical superintendent of St. Luke's Hospital, was one of the first professional psychiatrists who taught his subject to younger physicians, teaching that there was no specific treatment for the causes of madness; only techniques for treating its symptoms. Many patients, he argued, recovered if simply confined in peaceful surroundings protected from the upsetting visits of friends and the teasing of sightseers (a remark aimed at Bethlem where, as Pepys recorded in his diary, the patients were on show as in a zoo). During the first half of the Nineteenth Century sightseers ceased to be admitted to Bethlem. Insane offenders were gradually transferred from the jails to the asylums and most of them were later concentrated in Broadmoor. The newer asylums were deliberately built away from the towns in the peace of the countryside. The mentally deranged person became a less familiar sight in open society. With the accession of the eighteen-year-old Queen Victoria, decisions concerning admission to mental hospitals in capital cases passed from her council into the hands of the Home Office. In 1840 a bill was passed by which certification could be carried out by two Justices of the Peace and two doctors. The disposition of the insane had passed from the family to the monarch into the hands of the medical and legal professions.

In North America the origin of the asylum and mental hospital as well as the development of the penitentiary system was based to a large extent on theoretical concepts concerned with the cause of insanity and crime, and differed in several respects from the traditional development and empirical solutions which had characterized British practices (Rothman, 1971).

In North America the first colonists attributed insanity to the will of God. The insane, like the poor or disabled, were dependent on their families and cared for in the community. Somkin, in his examination of changes occurring in the American identity in the years between the revolution and the return of the revolutionary hero Lafayette in 1824, quotes the view on the effects of the rapid increase in American prosperity, "that it had somehow turned a nation of God-fearing freedom-loving idealists into a grasping horde of mercenary egotists." (Somkin, 1971). Somkin explores the "social concern" that beset the new Republic and in this context there developed "one of the most articulate and elaborate statements of the social origins of deviant behaviour. . . in the pre-civil war analysis of the causes of insanity." (Rothman, 1971). By the 1830s it was thought (incorrectly) that an epidemic of insanity was over-running the country. Physicians and superintendents of hospitals turned their views away from medical explanations to share in the general misgivings about the course taken by American society, already in the process of de Tocqueville's speculative analysis (de Tocqueville, 1947). In the terms of a critique of Jacksonian Society, insanity along with other social evils such as crime and poverty was found to be the result of social breakdown. Every aspect of society was weighed and found wanting, engendering the concept that "Mental disorder is part of the price we pay for civilization." (Jarvis, 1851). Specific areas of social debility were indicated.

Competition for wealth and business led men "to aim at that which they cannot reach, to strive for more than they can grasp. Overtrading, debt, bankruptcy, sudden reverses, disappointed hopes all seem to have clustered together in these times and are generally influential in producing insanity." (Woodward, 1839).

In politics men competed for power and "paid the price of insanity for their ambition." (Rothman, 1971). Overzealousness applied to intellectual pursuits also:

> Today we question everything, pry into everything. . .subjects which were once supposed to be confined to the province of the learned are now discussed by an order of minds which disdains the trammels of logic. The family and school provided no remedies. This generation has scarely felt any will but their own, obeyed no higher law than the caprice of the moment. Family government had weakened so that children contemplated life not as a field of discipline and improvement but as a scene of inexhaustible opportunities for fulfilling hope and gratification. With such

> training patience and perseverance become distasteful to a mind which can breathe only an atmosphere of excitement. It reels under the first stroke of disappointment, turns upon itself. . .and thus. . .becomes insane. (Ray, 1863)

The school was also seen to promote struggle, competition, and achievements "showy but no solid;" and these defects led to "nervousness, quarrels and despondency." (Rothman, 1971, p. 121).

If wealth led to artificiality and dissipation, poverty on the other hand brought about the struggle for subsistence, ill health, domestic strife and the temptation of alcohol as an escape. Perils lay on every hand in the urban street: 'taverns, theatres, and houses of prostitution', threatening the stability of society, were held responsible for crime and insanity. Preachers, reformers, physicians, superintendents and other officials and representatives of social order felt the passing away of the regularities of Eighteenth Century society. The passing of the old order with uncertainty of what would replace it was surely the presage of what Toffler has described as 'future shock' (Toffler, 1970). The new elements were perceived as corrupting and provoking. So uneasily was individualism born in America.

With our own hindsight we can see to what extent those fears were amply justified; and also that they were in their general notions of cause and effect often unsophisticated. What of their solutions?

There appeared to be no possibility of halting the flood of change or of restoring social stability. Instead it was planned to design and oversee an environment intended to erase irritations, tension and chaos, to restore the insane to health. The insane asylum thus conceived resembled Utopian communities or model societies, not to test theories of industrial production, economics or political harmony, but to show that a regular and disciplined routine could protect the insane from the perils of the community, and also to further a reform programme demonstrating to the larger society the benefits of such a system. Thus medical superintendents and their lay supporters moved to create a new world for the insane, one that would not only alleviate their distress but educate the citizens of the Republic.

The construction of insane asylums in North America proceeded rapidly in the first half of the nineteenth century and by 1860, 28 of the 33 states had such public institutions. "A cult of asylums swept the country." (Rothman, 1971) It was believed that by this method insanity was curable, more than most other illnesses. Grandiose estimates of cure were self-perpetuating.

The institution was the instrument of cure. It would entail a discipline routine to curb uncontrolled impulses and provide the order and stability lacking in society. "Medical superintendents and penitentiary designers were as eager as Owenites to evolve and validate general principles of social organization from their particular experiments." (Rothman, 1971) To achieve this special milieu the appropriate arrangement of the asylum, its physical dimensions and daily routine monopolized their thinking. Thomas Kirkbride published a text book *On the Construction, Organization and General Arrangements of Hospitals for the Insane*, in which he discussed the size, location and construction of buildings, the dimensions of rooms; how to group patients, how to staff hospitals and occupy the inmates during the day.

The first postulate of the asylum programme was to remove the insane from the community. Treatment in the family was expected to fail. Ray conceded that "to sever a man's domestic ties, to take him out of the circle of friends and relatives most deeply interested in his welfare, and place him in the hands of strangers and in the company of persons as disordered as himself, would seem little likely to exert a restorative effect." However, in the hospitals he would be "beyond the reach of all causes of excitement," and this was seen as the key to treatment and the route of escape from the pressure and anxieties of ante bellum society. Away from the town in tranquil and natural surroundings, a quiet, regular routine was prescribed which was intended to be neither overcontrolled nor overindulgent. Visiting and correspondence were restricted to protect the inmates from ideas from outside. The placement of the asylum outside town centres was attractive because land value was cheaper. It was not, however, the result of communities' being threatened; on the contrary budding towns and growing suburbs competed to have institutions in their midst, believing that the income and employment would compensate for the nuisance. A fixed calendar of daily labour and recreation was the programme for what was called 'moral treatment.' Rising, dressing, washing, meals, labour, occupation, amusement, walking, riding, and entertainments all took place at carefully prescribed hours. Emphasis was placed on kindliness and attendants were exhorted "to be tender and affectionate, to speak in a mild persuasive tone of voice." The patient was to be soothed and calmed when irritated. Violence was to be avoided at all costs. These precepts were probably upheld. For example Kirkbride, reporting for the year 1842, stated that out of 238 patients one woman and seven men had been subject to forms of mild restraints. A minimum commitment of from three to six months was initiated at this time. Chronic and poverty stricken patients became a captured population. The community image of the asylum was that of a well-ordered family. For example, the superintendent at Utica stated that "our household is divided into ten distinct families", and Samuel Woodward (1839-44) described his patients as "a quiet and happy family enjoying social intercourse, engaging in interesting and profitable employments, in reading, writing and amusements." Punitive features of the penitentiary such as special haircuts and head shavings were absent, but in fact the regimentation resembled, rather than a permissive family, the modern factory of punctual routine and inflexible schedules.

Architectural structure of the asylum reflected its function, based on a frequently repeated design in which a central imposing structure (surmounted by a cupola) in which the superintendent lived, was attached to radiating wings where the patients were housed. An alternative arrangement was provided of buildings scattered over the grounds which bore more resemblance to the village, particularly when the buildings were small, but often they were not.

The asylums suffered a dramatic decline from reform programmes to custodial care, and by 1870 moral treatment was seen to be inadequate and insanity not susceptible to this straightforward remedy. The idea of the asylum, however, remained central to public policy. Overcrowding, inadequate funds, and understaffing marked the decline. Harsh treatment and the use of mechanical restraints including boxes, straight jackets and cuffs began to appear in hospital reports. The emphasis on work as therapy declined; patients were often to be found sitting around moping, unoccupied. Physicians criticized the neglect. Hammond (1879) declared that "segregation was not only unnecessary but positively injurious," and that "a violent rupture of social and family ties is especially injurious and association with lunatics far more profoundly affected than themselves cannot have but a highly pernicious influence. . .hospitals of all kinds are to some extent evils." The best course of action was to "keep mentally deranged patients at home or with friends so long as this could be done with safety."

Thus the controlled environment of the asylum passed from denoting positive expectations to those of negation and despair, conferring on asylums a stigma from which they are not yet fully recovered. In the past twenty years a number of studies have been made of the institutional milieu (Caudill, 1958; Goffman, 1961). Treatment in the mental hospital has applied more to those of low socio-economic status who also have more difficulties in communication about their problems and are more socially distant from professional workers (Hollingshead and Redlich, 1958; Harde and Feinhandler, 1959). The professional workers themselves have been organized in 'line hierarchies' emphasizing differences of status and conflict in communication (Stanton and Schwarz, 1954; Loeb and Smith, 1957) not entirely resolved by the development of the 'treatment team.' Perhaps the most disconcerting aspect of the mental hospital as a facility for diagnosis and treatment has been the demonstration that healthy imposters may be labelled as insane once they had been admitted, although fellow patients often perceive the deception correctly (Rosenhan, 1973). Goffman's essay on the "Moral Career of the Mental Patient" (1961) and the observations of Scheff (1966) and others show that the institutional environment can condition the patient to maintain the role of the mentally ill or sick person, and result in the establishment of a stabilized identity in that role.

In the mental hospital where I work gradual changes have been brought about in the past ten years which have had the effects of increasing self-determination for the patient, and providing expectations for role involvements more compatible with the independent life in the community. Such innovations are being widely discussed and implemented. Some of these changes have been the result of specific technical innovations (pharmacological therapy, behaviour modification, industrial training programmes, for example) but much has had to do with the expectation becoming redefined as the result of changes in the milieu and the staff-staff, staff-patient interaction. Most of these changes are exemplified by the work carried out in the Rehabilitation Unit under the supervision of a psychologist, Dr. R. Van Allen, and directed towards those patients for whom the label 'chronic' had formerly denoted small expectations of independence. These comprised chiefly those diagnostic categories of chronic psychosis (mainly schizophrenia), mental retardation and brain damage.

Efforts were made in 1964 to improve the treatment of the former group by the establishment of a continuing care unit. During the next four years retarded and chronic psychotic patients were separated and a retardation unit and a continuing treatment unit were established. In 1966 a token economy was established on one ward and this was extended to three wards by 1971 to include both retardates and chronic schizophrenics. The question of payment of patients and expectations that they should work had been a dilemma for the hospital for many years. Fluctuations in policy occurred varying from the opinion that patients should not be expected to work at all, to the expectations that they should be expected to work for nothing on projects which were of material value to the hospital. In addition, occupational therapy had been practised with a view to stimulating interest and increasing individual productivity. The development of token economies has been used in a much more specific way not only to improve management but to reinforce useful social behaviour and skills that will make the patient more confident and more responsible, and which will increase his sense of belonging to, and functioning in, a small community and increase his sense of self-worth. By such methods behavioural control is used to bring patients to an increased degree of freedom, by increasing their competence.

From about 1970 treatment teams were used composed of staff previously employed in the hospital. These were chiefly nurses, social workers and psychologists and they conducted both group and individual therapy in which one would be primary therapist for a particular patient. Integration of the sexes took place on two chronic wards in 1970, and in 1971 the chronic wards were reorganized according to their function: intensive treatment ward, token economy, prehostel and hostel. In 1972 the first cooperative home was developed in the community for eleven patients and in 1973 a second home of the same kind was begun. Patients were discharged to live together in a residence with university students also lodging there.

This programme has been built up in a step-like fashion, adding facilities as more patients were ready to use them. The programme has had many facets: individual behaviour therapy, contractual arrangements between staff and patients, group therapy focusing upon reality-oriented discussions dealing with current problems, the development of a drug clinic for schizophrenic patients, the use of mutual aid between patients with staff acting as advisors, the encouragement of patients to stay together when they leave hospital until they have found friends independently in the community, the use of day and night hospital care for use in transitional situations; the increasing use of community resources including vocational programmes, on-the-job training, social services and education programmes; the cooperative homes in the community or the placing of patients with families (not relatives) for supported living arrangements. This programme has shown that conventional treatment and behavioural control can be combined with the development of a sense of community involvement to help patients who in former years would have remained in the back wards of the hospital.

Changes brought about in hospital may not be easily transplanted into the community (Paul, 1969). Community care requires independent planning whether it is to follow hospital experience or intended to circumvent it.

Since mental hospital treatment may be ineffective or even negative (Ellsworth, 1968; Kantor and Gelineau, 1969; Graziano and Fink, 1973), should the asylum be done away with entirely? It is not likely in the present era of population expansion and urban social problems that this could take place easily without the development of alternative environments in the community; for some the hospital remains the only society in which they can live. Improvements in the hospital milieu require the continuing and innovation of specific methods and goals for the individual patient. These may be described as individual patient programming with emphasis on staff training, primary therapist relationships to ‘see the patient through,’ the development of records and review systems designed to focus on individual problems and goals, (Weed, 1971; Richman and Pinsher, 1973) and a system of follow-up, evaluation and continued treatment of relapse or treatment failure.

A residue of patients will still remain in hospital indefinitely or for relatively long periods of time. Before we can assume that improved techniques will afford overall solutions we should think back to the innovators of 'moral treatment.' Are we able to avoid the path they trod, paved with good intentions?

The mental hospital still has the connotation of a controlling environment but so has the technological society in general. Fear of control through 'therapy' is also expressed towards techniques of behaviour modification such as conditioning, psychosurgery and the use of drugs. Technological society engenders such fears and the alienation associated with it, which Moryama (1973) perceives a deriving from a characteristic mode of dominating our environment.

> This aggressive competitive attitude is drilled into us at an early age so that we are hardly aware that we live it day after day. It is reinforced by the grading system in schools, competitive sports, beauty contests and the like. Motives are always suspect; mutual trust and human dignity lost. In this context, to define a healthy society as one in which people are encouraged to develop their potential for love, cooperation, achievement and growth, sounds like a hopeless visionary ideal. . . Mayeroff defines ("On Caring") true caring whether for another person, an idea, a community or an environment as the convergence of want and ought. . . Mayeroff is more interested in the process than in the products of growth. Finite goals are a distraction and life is made flat and empty by reaching them.

The goal of the environmentalist is co-existence, in which goal and process are the same thing. It is in this sense that technical processes and the caring for and tending of human relationships must converge in the redefinition of the asylum, and in the definition of our relations not only person to person but with the natural world, expressed by Voltaire and by Ian McHarg (1973) through the metaphor of the garden.

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A Programmed Environment for the Experimental Analysis of Individual and Small Group Behaviour

G. E. Bigelow[1], H. H. Emurian and J. V. Brady

This paper describes a unique methodology for the study of small groups: that of establishing a self-contained, continuously programmed, experimental social environment. The term programmed environment refers to a setting in which conditions exist for manipulating or influencing a substantial portion of the behaviour of participants. Thus, its principal distinction is the high degree of experimental control which is brought to bear upon variables influencing individual and social behaviour. Development of this methodology is the result of the need for empirical research in the area of social functioning, the limitations of present methodologies, and the demonstrated utility of this experimental approach within other contexts.

In a recent review of research on small groups, Helmreich, Bakeman, and Scherwitz (1973) refer to their disenchantment with the significance of the current literature as well as their depression with the general absence of excitement in the area. They indicate that the vast majority of studies in social psychological effects have dealt only with acute reactions assessed over a brief period of time. These authors seem to feel that new life might be brought to the area if research shifted away from acute experimental studies to more long-term observation of the functioning of natural groups. These authors seem to feel that for the study of human behaviour the experimental method is applicable primarily to acute situations, and that non-experimental observational techniques are most appropriate for the study of longer term processes. However, this separation of methods appears to be based upon considerations of convenience and practicality rather than upon scientific utility, and need not occur.

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Application of a rigorous experimental methodology involving the systematic manipulation of relevant controlling variables would certainly appear to offer the greater opportunity for determination of valid functional relationships. Clearly, the application of such rigorous methodology to the study of the complex individual and social performance repertoires involved in the continuous daily functioning of a society should broaden the applicability and generalizability of behavioural science principles. However, the opportunities for exercising the necessary degree of experimental control within a functioning society are indeed rare.

The necessary research mechanism would seem to be provided by the establishment of an experimental microsociety environment which incorporates the broad range of naturalistic behaviours typically involved in individual and social functioning, and which is under direct experimental control. The present paper describes such a laboratory, in which small groups (up to six individuals) can be continuously maintained and studied for substantial periods within an experimentally controlled and programmed environment which is isolated from external social contacts.

This laboratory development and research programme is a direct outgrowth and extension of earlier worl by Findley, Migler and Brady (Findley, 1966) in the development and evaluation of a continuously programmed environment for an isolated human subject. Their work demonstrated the feasibility of maintaining continued subject participation and productivity within such an environment, and also established that such environments can provide stable behavioural baselines upon which to conduct systematic experimental manipulations. Extension of the programmed environment methodology to a social setting represents a significant addition to social psychological research methodology.

The present programmed social environment makes possible both objective measurement and experimental control, two prerequisites to an experimental analysis. Objective measurement has been achieved by subdividing the total behaviour repertoire into a series of behavioural units for which the frequency and duration of each can be measured via direct observation or interfacing with environmental control mechanisms. The term "experimental control" has two meanings. On the one hand, it represents the ideal of establishing a relatively constant environment in which to conduct experiments – control of extraneous variables. On the other hand, experimental control refers to the capability to manipulate experimentally relevant variables within the experimental setting. The programmed environment described here provides for experimental control in both senses. Extraneous variables are minimized by dealing with a closed social system within an isolated experimental setting. The ability to manipulate relevant environmental variables is made possible by the programmed nature of the environment as exemplified by the development of behavioural programming procedures, as described subsequently.

The continuously programmed environment research approach described here represents, on four counts, a significant extension of experimental methodology for the study of small groups: (1) it brings within the laboratory a broad range of complex and naturalistic units of behaviour seldom submitted to experimental analysis; (2) it permits the study of conditions and processes of considerably greater duration than does the typical acute social psychological experiment; (3) it permits direct objective observation and measurement of the behavioural units under study;

(4) most importantly, it permits the direct programming and manipulation of units and patterns of individual and social behaviour.

PHYSICAL DESIGN

The goal in the design of the physical environment has been to permit a considerable range and flexibility of research usage within the constraint of maintaining a high level of experimental control. Certain of the specific physical design characteristics result, of course, from the multiple constraints imposed by attempting, within the fixed and limited total floor space available, to satisfy a variety of specific research-related goals. These research-related design goals are reflective of our own dispositions with respect to (1) the areas of investigation for which this laboratory is appropriate, (2) the technical style of research practice believed most likely to reveal meaningful relationships, and (3) the classes of variables which are likely to exert potent controlling influences.

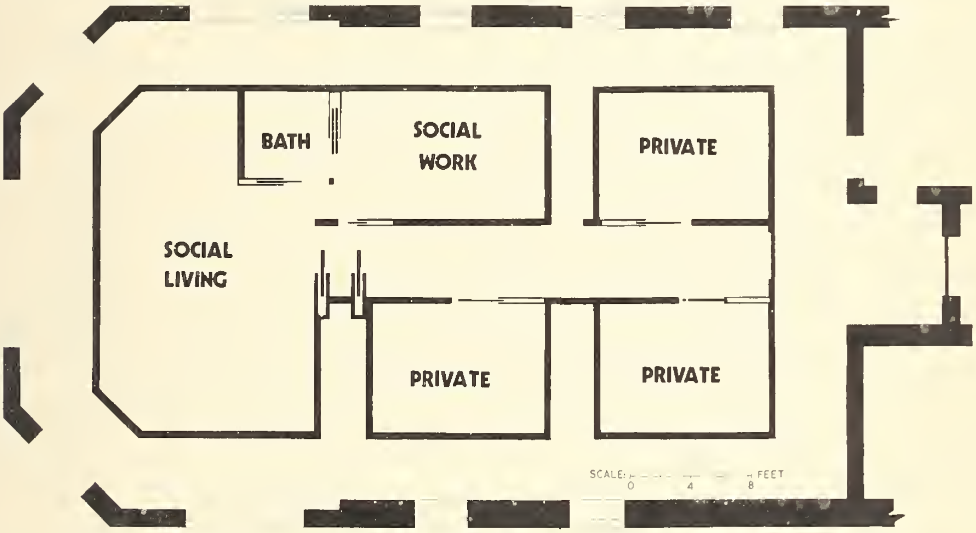

Figure 1 *Floor plan of the programmed environment laboratory.*

Examples of specific research-related design considerations are as follows: the environment should contain an array of facilities sufficient to permit the continuous residence of participants. Facilities should be sufficient for a minimum of three residents. The arrangement of facilities should permit but not demand social interaction or social living by the participants. Isolation of participants from external social contacts should be possible. Requirements of experimenters' intrusion into the environment for maintenance and materials exchange should be minimal. Provisions should exist for experimentally controlling access to physical facilities. Objective recording of participants' behaviour should be provided for.

The resulting experimental environment consists of a complex of five specially-designed rooms constructed within a wing of the Phipps Clinic of the Johns Hopkins University School of Medicine. The overall floor plan of the laboratory and its arrangement within the external building shell is depicted in Figure 1. There are three identical one-room private apartments (each 8-1/2 x 11 feet), plus a large social living area (14 x 22 feet) and a social work area (8-1/2 x 13-1/2 feet), all interconnected by a common corridor. These are arranged such that the experimenters have external access to most walls of each area.

Each living area (private and social) is a complete, self-contained living unit, containing the fixtures and furnishings necessary to permit continuous residence by participants – kitchen, bath, bed, table, chair and storage facilities. Each private area can support a single individual; the social area can support three individuals. The social work area provides a work bench and storage facilities for work tasks and supplies, and contains a washer-drier unit for laundry. Selected storage facilities in all areas are accessible both to participants inside the environment and to the experimenters outside so that transfer of supplies may be made without external intrusions. Each room contains a programme console for display and selection of behavioural schedules. Figure 2 depicts the specific arrangement of facilities within the private living areas.

A primary consideration in the programme design has been the association of behavioural units with specific elements of the physical facility. A series of remotely controlled solenoid locks throughout the environment place access to the various facilities and areas of the laboratory under experimental control. Thus, since particular behavioural units require access to particular sets of environmental facilities, control over the physical facilities of the environment is translated into control over behavioural units. For example, access to the storage area containing materials for a specific activity (e.g., work supplies or reading materials) is permitted only when that particular work or reading behavioural unit is scheduled. Correlation of

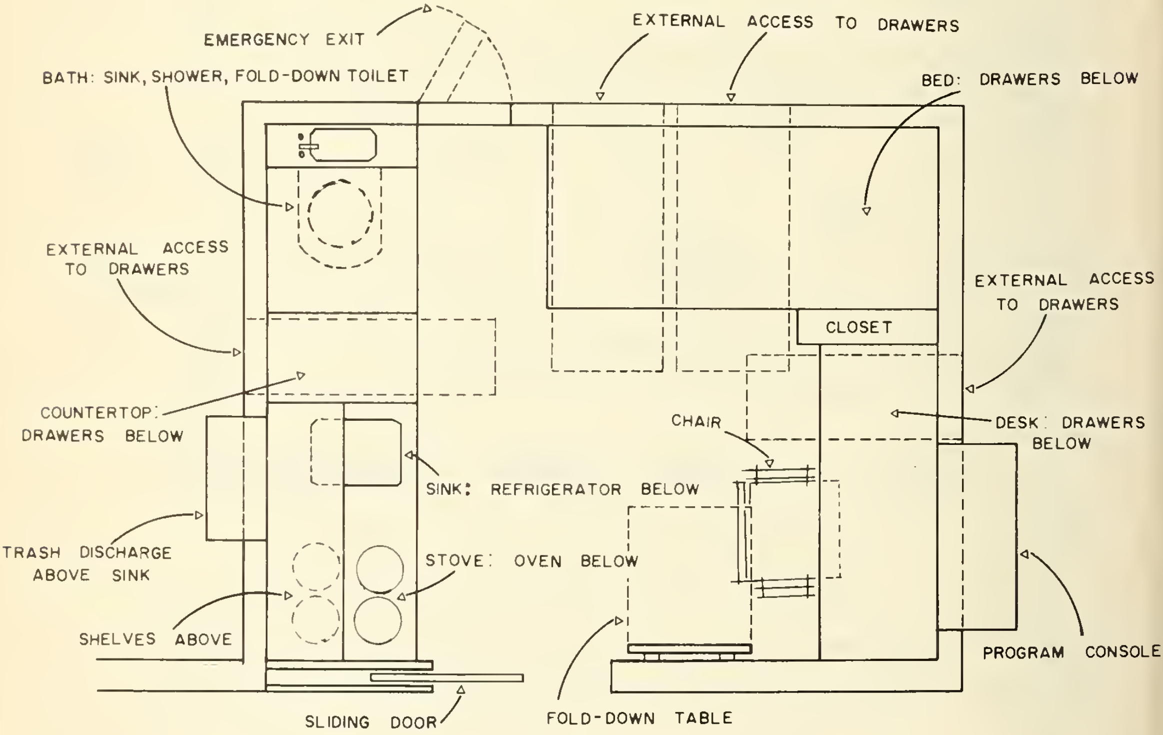
EMERGENCY EXIT
BATH: SINK, SHOWER, FOLD-DOWN TOILET
EXTERNAL ACCESS TO DRAWERS
BED: DRAWERS BELOW
EXTERNAL ACCESS TO DRAWERS
EXTERNAL ACCESS TO DRAWERS
CLOSET
COUNTERTOP: DRAWERS BELOW
CHAIR
DESK: DRAWERS BELOW
SINK: REFRIGERATOR BELOW
TRASH DISCHARGE ABOVE SINK
STOVE: OVEN BELOW
SHELVES ABOVE
PROGRAM CONSOLE
SLIDING DOOR
FOLD-DOWN TABLE

Figure 2 *Detailed floor plan of a private living area, showing the locations of facilities.*

behavioural units with physical facilities seems desirable from the point of view of establishing stimulus control over activities, as well as from the more general vantage of ease of establishing experimental control.

Social interactions within the environment can be regulated in the same manner as other behavioural units, that is, by controlling operation of or access to the relevant physical facilities. These include a telephone intercom for communications within the environment and potentially with the experimenters; an audio monitor system permitting subjects to listen in on other locations within the environment; and a video monitor system which permits subjects to view other areas within the environment or to view programme material selected by the experimenters. Subject movement within the environment can be similarly regulated. Remotely controlled controllable solenoid locks on all doors prevent unscheduled entries. Upon entrance to, or departure from the social areas, subjects must pass through a "transition" cubicle for identification and routing to the appropriate room (see Figure 1). This transition cubicle constitutes an "air lock" chamber to verify that each subject who passes through is identified and routed only to scheduled areas.

The electromechanical environmental control devices are interfaced with a minicomputer for remote scheduling and determination of environmental functioning capabilities. In addition to control of environmental facilities functioning, the computer can concurrently accumulate data and provide schedule information or instructions to the participants via cathode-ray tube (CRT) displays within each room. The alpha-numeric keyboard on the displays provides participants with the capability of direct communication with the system control to indicate initiation of behavioural units and to indicate individual activity selections when options are presented in the behavioural programme. These subject responses on the CRT keyboard can automatically activate the relevant facilities and begin automatic data recording. In addition to these data, audio and video monitoring equipment in each area of the environment provides experimenters with continuous information concerning all subjects' activities.

BEHAVIOURAL PROGRAMMING

Although control of access to the physical facilities associated with behavioural units contributes to the development of a behavioural programme, the term "behavioural programming" refers to more than just the automation or remote control of physical facilities. Behavioural programming refers to the experimental scheduling of behavioural events.

The aim of behavioural programming is experimental control desired for two purposes: (1) to establish stable performance baselines upon which the effects of manipulated variables may be revealed; and (2) to permit the direct manipulation of performance as an independent variable.

A behavioural programme can be conceptualized as consisting of two components: the array of activities or behavioural units included, and the rules which govern the inter-relationships between these activities or units. These elements provide the ingredients and structure by which the controllable characteristics of the laboratory are translated into experimental control of behavioural units.

The nature of the particular behavioural programme selected for use is determined by the nature of the particular problem under experimental study. A multitude of behavioural programmes can, of course, be developed which lie along a continuum ranging from the relatively impoverished minimum ecology necessary to sustain an individual, to as rich, varied, and complex a programme as environmental resources will permit. Clearly, an interplay will exist between the complexity of the inventory of activities and the potential complexity of the rules which may govern their inter-relationship. As the inventory becomes more extensive, the rule structure may become more intricate. Thus, it should be emphasized that behavioural programming does not necessarily imply the rigid, lockstep scheduling of a repetitive sequence of activities. Behavioural programming is a very flexible procedure which can be utilized to attain a variety of different performance baselines – ranging from a rigid and repetitive sequence to complex branching programmes including a multitude of personal options.

One prerequisite for behavioural programming is that the available behavioural repertoire be subdivided into manageable units. An effort has been made to specify behavioural units which possess some operational or functional unity. Thus, broad performance categories have been selected for analysis rather than more detailed moment-to-moment qualities of performance. Table I presents a summary of the behavioural units incorporated into a typical programme.

The intent has been to establish an environment in which behaviour will occur as a function of conditions and contingencies prevailing within the microsociety, rather than as a consequence of subjects' unique individual histories outside the experimental setting. This statement is not intended to denigrate the significance of individual differences, but rather to indicate that control was sought over variables sufficiently potent to reveal their effects despite individual differences. Thus, the major class of variables with which the rule structure deals is that of the temporal, sequential and contingent relationships among behavioural units, in other words, the specification of the times and durations of activities, of the order in which activities occur, and of which activities are required to gain access to other activities. These are a class of relationships which have been demonstrated to exert powerful control over behaviour, but which have not been generally accessible to detailed experimental control and manipulation within a continuous residential setting.

The rule structure that has been adopted in our preliminary efforts to develop a satisfactory baseline behavioural programme is modelled after a chained schedule of reinforcement such as was successfully employed with a single participant in a previous study by Findley, Migler, and Brady (Findley, 1966). In that study, chains or sequences of activities were presented, and all of the requirements associated with one activity had to be completed by the participant before the next activity in the sequence became available. Both fixed and optional activities were available, and the activities were generally arranged sequentially in such a way that more desirable activities followed less desirable activities, and a greater number of options were available later in the sequence than early in the sequence. These contingent relationships between activities, the sequential arrangement of activities, the distribution of scarce reinforcers within the total repertoire, and the precise stimulus control and measurement associated with each activity illustrated the application of fundamental behaviour principles to the maintenance of a complex human repertoire.

TABLE I

INVENTORY OF BEHAVIOURAL UNITS WITHIN REPRESENTATIVE PROGRAMME

Abbreviation of Unit	Full Name of Unit	Brief Description of Behavioural Unit
H✓	Health Check	Temperature, pulse, subjective report
PE	Physical Exercise	Light calisthenics, 10 minutes
TO	Toilet Operations	Use of bathroom and contents of TO drawer – toiletries, clean clothing
AB	Autogenic Behaviour	Relaxation and concentration exercises on tape
FD1	Food One	Two selections from a list of light foods
WK1	Work One	Social, cooperative paced contour tracking task
SLP	Sleep	Unlimited use of bed surface
WK2	Work Two	Varied problems, experiments, and construction projects
PI	Programmed Instruction	Access to book or programmed material
PA	Puzzle Assembly	Social, cooperative assembly of a puzzle
MB	Manual Behaviour	Access to art materials
MU	Music	Earn one cassette tape
SR	Social Recreation	Social, access to games in social area
FD2	Food Two	Private major meal
FD3	Food Three	Social, major meal in social area
REQ	Requisition	Earn delayed delivery of treats or replenishment of consumables
COM	Communication	Access to intercom
LTO	Limited Toilet Operations	Access to commode

An alternative rule structure which might be implemented and evaluated involves programming by economic rather than sequential contingencies (e.g., Ayllon and Azrin, 1968). Economic and sequential contingencies can be viewed as related techniques existing on a continuum. In fact, most economic or sequential rule structures will involve elements of the other. In the present case, a predominantly sequential contingency arrangement has been seen as providing the more precise degree of experimental control over behaviour.

A REPRESENTATIVE BEHAVIOURAL PROGRAMME

In the present research project behavioural programmes have been selected whose activity inventories provide for a broad range of individual work, educational, personal hygiene, and sustenance activities, a variety of direct (*i.e.*, face-to-face) social work and recreational activities as well as more indirect social interaction via intercom communication. Thus, these activity inventories are intended to provide a rich ecological setting which incorporates a variety of naturalistic behavioural units such as may typically be involved in complex individual and social functioning.

Table I describes the inventory of behavioural units included in a representative behavioural programme which has been in recent use. Figure 3 presents a diagramatic representation of the rule structure which has governed the temporal and contingent relationships among these units. Each box within the diagram denotes a specific behavioural unit. Subjects progress through the programme temporally from left to right. This is a branching programme containing a fixed activity sequence and an optional activity sequence. Regardless of the sequence selected, the diagram represents that all behavioural units are scheduled on a contingent basis one to another, such that access to a succeeding activity in the programme demands satisfaction of the requirements associated with the preceding behavioural unit.

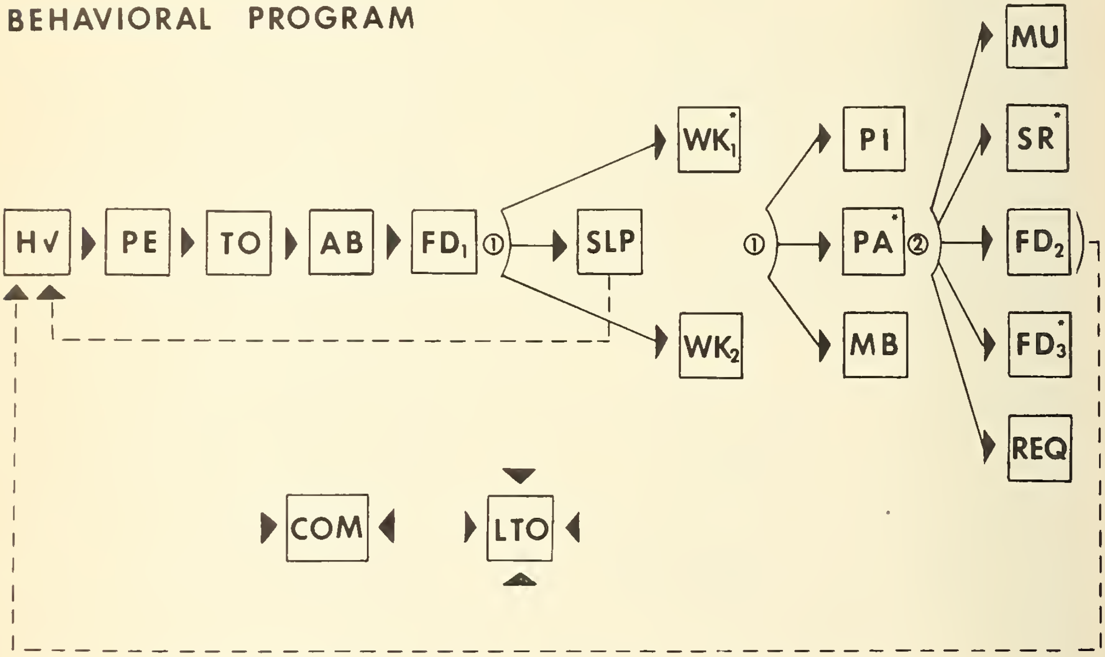

Figure 3 *Schematic diagram of a representative behavioural programme.*

For illustrative purposes, a detailed description of the functioning of this programme follows. This particular programme has been designed for, and utilized with, groups of two participants. In these early applications the corridor connecting the two private rooms has served as the social area for direct social engagements. In addition, this programme has been utilized in advance of achievement of the full level of automation of environmental facilities described earlier. Although this behavioural programme has, thus, not utilized the full range of the laboratory's facilities and capabilities, a description of its functioning can serve to clarify the nature of this experimental approach.

Beginning at the left of the Behavioural Programme diagram (Figure 3), the fixed activity sequence is composed of all activities between and including H✓, or Health Check, and FD 1, or Food One. The Health Check activity requires the subject to take his temperature and pulse, and to fill out a subjective status questionnaire. Once a subject has selected and completed Health Check, he then completes the following activities in the order displayed: PE, or Physical Exercise, in which 10 minutes of light calisthenics are required; TO, or Toilet Operations, allowing access to the bathroom and a drawer containing fresh clothing, towels, toiletries, and a vacuum cleaner; AB, or Autogenic Behaviour, in which the subject follows taped relaxation and concentration instructions; and FD 1, or Food One, in which the subject is permitted to select two items from a list of eight light foods such as coffee or tea, soup, cereal, etc.

When Food One is completed, the subject is eligible to select one of the following three activities: WK 1, or Work One, in which the subjects enter the social area simultaneously to operate the cooperative paced contour tracking task; SLP, or Sleep, which allows access to the bed for an unlimited time; and WK 2, or Work Two, which requires the subject to complete various problems, experiments or construction projects presented in the Work Two drawer. If the subject chooses Sleep, the dotted line on the diagram originating below the Sleep notation indicates that he is required to return to the Health Check activity and resume the fixed activity sequence at the completion of Sleep. Thus, this minimum recycling sequence is composed of activities designed to maintain and assess the subject's health if he is otherwise indisposed to engage in the broader selection of behavioural opportunities available within the full behavioural programme.

The optional activity sequence commences with the choice of either Work One or Work Two instead of Sleep. At the completion of either Work One or Work Two, the subject is eligible to select *one* of the following three activities: PI, or Programmed Instruction, involving a minimum of 30 minutes access to books and programmed educational material contained in the PI drawer; PA, or Puzzle Assembly, in which subjects are required to assemble a puzzle together within the social area; and MB, or Manual Behaviour, involving a minimum of 30 minutes access to art supplies contained in the MB drawer. At the completion of the selected activity, the subject is then eligible to select, one after another, *two* of the five activities presented in the last column of the behavioural programme: MU, or Music, allowing the subject to earn a cassette tape that can be played at any time during the programme; SR, or Social Recreation, allowing the subjects to enter the social area simultaneously to engage in games or visit together; FD 2, or Food Two, providing the subject with a major meal; FD 3, or Food Three, providing each subject a major meal to be consumed socially within the social area; and REQ, or Requisition, allowing the subject to earn points exchangeable for treats such as soft drinks, pastries, alcoholic beverages, or for staples such as soap and toothpaste. Once the subject has completed the second of his two choices among these five activities he returns to H✓ and resumes the fixed activity sequence, as the dotted line originating after the last column of activities on the behavioural programme diagram indicates. Thus, the optional activity sequence allows the subject a degree of flexibility with respect to the selection and arrangement of activities, both individual and social, that become available at the completion of the fixed activity sequence, and provides a broad selection of individual and social work and recreation activities.

At the bottom of the Behavioural Programme diagram are presented two additional activities: LTO, or Limited Toilet Operations, allowing access to essential toilet facilities, and COM, or Communication, allowing access to the intercom.

The Limited Toilet Operations activity is the only activity that can be selected at any time within the behavioural programme and thus interrupt an uncompleted behaviour unit.

A subject is permitted to use the intercom to initiate or answer a communication only if he is between any two activities within the behavioural programme. That is, interruption of an uncompleted behaviour unit to engage in Communication is not permitted. Such restricted access to the intercom is thought to provide more sensitive measures of communication dispositions (as reflected in overall frequency of both calls and answers, delays tolerated prior to aborting Communication and entering the next scheduled activity, willingness or unwillingness to disrupt or terminate a particular on-going activity to gain access to the intercom), than if Communication opportunities had been freely available. Additionally, scheduling intercom opportunities between activities serves to sharpen the stimulus control of Communication and enhance its functional integrity with respect to the other activities within the behavioural programme. Finally, an actual conversation requires both subjects' simultaneous presence within the Communication activity, although the location of Communication within the behavioural programme could be different for each subject. Intercom communications can occur between activities although subjects may be located at different sequential positions within the total repertoire. For example, a Communication might occur when one subject is between Autogenic Behaviour and Food One, and the other subject is between Manual Behaviour and the last column of activities, and so on.

All social activities other than Communication require a more precise synchronization of schedules. To engage in Work One, Puzzle Assembly, Social Recreation, or Food Three, both subjects are required to be simultaneously present at the respective location in the programme before the activity is made available. Typically, subjects will arrange by intercom to meet for a social activity several items in advance, then pace their tempos appropriately to synchronize their schedules.

This particular programme is being utilized in the study of factors relevant to the successful sustaining of small groups under conditions of isolation and confinement. The programme has been designed to permit the direct measurement of, with minimal programme changes, the manipulation of two factors considered likely to be of importance: the temporal speed of progression between behavioural units, and the rate of selection of social activities.

CONCLUSION

The laboratory and experimental methodology described here represent a unique approach to the analysis and study of complex human behaviour. A broad range of naturalistic individual and social performances can be brought into the laboratory and incorporated into the analysis of small group functioning.

Continuous residential settings have, of course, previously been utilized for both basic and clinical research purposes (Ayllon and Azrin, 1968; Alluisi, 1969; Altman, Taylor and Wheeler, 1971). Frequently, such studies have involved observation of individuals or groups within isolated environments with limited control over patterns of behaviour (Weybrew, 1963; Radloff and Helmreich, 1968; Helmreich *et al.*, 1972). The present laboratory appears to offer the unique combination of a pure experimental orientation plus experimental control over the full behavioural repertoire.

The high degree of experimental control made available by the present laboratory appears to represent its primary contribution. The approach described is obviously derived from the operant behaviour methodology utilized in basic animal research laboratories. Within such laboratories behaviour is brought under a high degree of experimental control. Consequent upon discrete environment stimulus changes, behavioural patterns may be abruptly and significantly altered in a predictable fashion. The intent has been to extend an approximation of this degree of experimental control over behaviour to the human social situation.

At present, four elements can be specified as important contributors to establishing such experimental control over behaviour: (1) isolation from the external environment; (2) remote control over functioning of environmental facilities; (3) the subdivision of the behavioural repertoire into functional behavioural units; and (4) the implementation of sequential behavioural scheduling programmes. The framework thus established provides the capability of applying a rigorous experimental methodology to the study of individual and small group behaviour. Application of such a methodology can be expected to offer a valuable extension of our understanding of human social functioning.

ACKNOWLEDGEMENT

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Research with Gibbons in a Designed Environment

J. B. Newkirk III[1]

INTRODUCTION

It is an increasingly accepted view among experimental psychologists and other students of behaviour that the behaviour of animals in cages is not necessarily representative of the behaviour of those same animals in their natural environments. This is especially true with the primates. The primate research centre of Hall's Island, Bermuda, recognizes this view and makes it explicit in its programme of behavioural and neurophysiological studies with the smallest of the anthropoid apes, the gibbon (specifically, the white-handed gibbon, *Hylobates lar*). The facility may be conceived as a "*midway designed environment* where unique research can be done intermediately between the restricted cage spaces of primate laboratories and the natural habitats of free-ranging wild gibbons" (Carpenter, 1973). This paper briefly describes Hall's Island and the research programme being conducted there.

The original idea for the establishment of a new primate centre grew out of a line of research started by A. H. Esser in the 1960s. Dr. Esser was interested in studying the natural behaviour of small groups of psychiatric patients. His aim was to develop methods for quantifying data on social interactions and to determine the extent to which variables such as territoriality, dominance hierarchy, and aggressiveness are correlated with the parameters of psychiatric disturbance and treatment (Esser, 1965, 1968, 1970; Esser *et al.*, 1965; Paluck and Esser, 1971 a,b).

Almost immediately, a need was felt to establish a non-human primate colony, in which greater intervention in individual behaviour was permissible than when studying humans, and with which it might be possible to develop a *model* of small group interaction. Consequently, in 1967 studies were undertaken of a group of captive gorillas at the Bronx Zoo (Esser and Paluck, 1968). Following this, a group of gibbons was studied in Hawaii (Paluck, Lieff and Esser, 1970). These studies demonstrated the feasibility of continued research, and the International Psychiatric Research Foundation offered support, on the condition that a location relatively close to the Eastern United States could be found. With the rental of Hall's Island in 1969 the plans for a "Center for Primate Research" were consolidated.

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N.B. The official title of Rockland State Hospital was changed by the New York State legislature in 1974 to "Rockland Psychiatric Center," after presentation of this paper.

A number of consultants and advisors from diverse fields, representing several universities and other institutions, were organized under the general directorship of Dr. Esser, to coordinate a varied programme on Hall's Island. C. R. Carpenter, Ph.D., was enlisted as consultant on gibbon behaviour and husbandry, and as principal investigator in a long-term programme of ethological research. Jose M. R. Delgado, M.D., was recruited to carry out a programme of neurophysiological studies using his well-known method for radio-remote electrical stimulation of the brain which can influence aggressiveness and dominance within primate groups (Delgado, 1967).

The first group of six juvenile gibbons was released onto Hall's Island in June, 1970. Two of these animals died the following September; one by accidental drowning and the other, presumably, as a result of an allergic reaction to an insect sting. These two animals were replaced early in the summer of 1971.

Late in 1971 another gibbon was found dead. Autopsy showed signs of cerebral hemorrhage. It was postulated that death in this case resulted from head trauma suffered in a fall, since it has been well established that wild gibbons frequently receive fractures in falls (Schultz, 1933). The group population remained at five until August, 1972, when an adult male was removed following an increase in the frequency and severity of his attacks on human observers. A few months later another of the original six gibbons drowned after nearly three years of normal growth and development without illness.

An adult, mated pair of brain-implanted gibbons was introduced to the island in July, 1973, but after three months the female of this pair also drowned. How the drownings occurred remains an unanswered question since none of the presumed accidents was witnessed. Thus, the present population of the island is four; two adult males and two adult females. Three of the animals have been on the island more than three years and have developed there, from juveniles through adolescence to adulthood. Species specific copulatory behaviour was observed in the summer of 1973.

THE GIBBON

Dr. Esser's success with the white-handed gibbon (*H. Lar*) in Hawaii led to his choice of this species for the Hall's Island primate group. The gibbon is the smallest of the anthropoid apes at an average weight of 5.2 kg (11.4 lbs.) for the females and 5.7 kg (12.5 lbs.) for the males at maturity. This small size permits the observation and *handling* of a non-human primate, near the top of the phylogenetic scale, without the risk of serious injury to animals or humans which is attendant with similar work attempted with larger anthropoids (chimpanzees, orang-utans, and gorillas).

The gibbon demonstrates considerable climatic and dietary adaptability as evidenced by its having one of the widest geographic ranges of all non-human primates and an altitude range from sea level to 7000 feet (Carpenter, 1964, p. 160). Delacour (1961) has reported that gibbons in a park in France thrived and reproduced at winter temperatures as low as -16°C (+3°F).

It is, however, those attributes of gibbon *social* behaviour, first described by Carpenter in 1940 (Carpenter, 1964) and later confirmed by Ellefson (1967), that suggest the greatest potential for gaining new insight into human behaviour. The pattern of social organization for gibbons in undisturbed populations generally conforms to that of the the monogamous nuclear family. Wild gibbons apparently mate for life, and each pair sets up and defends a territory. A single infant is born to the parents approximately every two years. For the first 1½ to 2 years of its life the infant is highly dependent upon the mother. At about seven or eight years of age the gibbon reaches subadulthood, splits off from its original family, finds a mate, and sets up a new gibbon family territory. As a result of this spacing, no gibbon family contains more than four offspring and two parents.

There is little fighting within gibbon families. Dominance is equally shared between the adult male and female, and is signalled through vocalizations, facial gestures, and other kinesics. In territorial conflicts with neighbouring gibbon groups, however, a great deal of aggression may occur. The conflict may include loud vocalizations, chasing, sparring, and attacking with the long sharp canine teeth which occur with equal size in both sexes.

In the introduction to Carpenter's 1940 monograph (Carpenter, 1964), Schultz expresses the conviction that the anatomical evidence demonstrates that the gibbons and man diverged from the same ancestral primate origins at about the same time and definitely before the three great apes differentiated. More recently, Carpenter (1973) summarized the view that the upright posture exhibited by the gibbons while swinging and walking, along with the distinctive social behaviour characteristics, strongly reflect assumed prehistoric humanoid traits, and thus, *if* there was an arboreal stage in human evolution, the gibbon may represent a living model of this adaptation.

THE ISLAND

Because gibbons do not swim, and, in fact, seem to have an aversion to going into even shallow water, a small island is an ideal setting in which to maintain a group of these animals in a relatively restricted space but without having to subject them to the confinement of caging. Several attempts were made in the past to establish planned island colonies of gibbons for intensive behavioural studies. Most noteworthy were Cayo Santiago in Puerto Rico, circa 1938-1940 (Carpenter, 1972), Ko Klet Kaeo Island in Malaya (Berkson *et al.*, 1971), and Laulanui Island, Hawaii (Paluck *et al.*, 1970). Cayo Santiago is now used only for monkeys. For a number of reasons, the other two attempts have also been abandoned (Carpenter, 1973). Hall's

Island is the latest such attempt and as it completes its fourth year, it shows every indication of continuing success.

Hall's Island is a steeply crowned, pear-shaped island of fossil coral near the eastern edge of Harrington Sound, Bermuda, at approximately 32°N. latitude and 65°W. longitude. The island is almost 400 ft. long and up to 100 ft. wide, with a total surface area of 1½ acres. The long axis of the island is oriented north and south (Figure 1).

Figure 1 *Southern half of Hall's Island looking toward west. NOTE: Warning sign posted near boat landing area, lower left; food shed, left center; rope trail system, right center; observation tower, upper right.*

The western boundary of the island is formed by steep, undercut cliffs rising to 30 feet. From the highest point, nearly at the centre of the island, the ground slopes sharply downward from a height of 50 feet to the westward cliffs and northern shore. The ground slopes more gradually toward the east and south. The topography of the island gives the general impression of a plane tilted downward from west to east along its long axis.

The surface is of porous limestone with only a few inches of soil, but this supports a hardy vegetation forming two distinctive communities. The southern end of the island is characterized by an open grassy area which is bounded by succulents, prickly-pear cactus, yuccas, and low shrubs. A few palmettos and casuarinas are scattered over this area. The middle and northern areas of Hall's Island are covered with dense shrubs and woody bushes to an average height of over eight feet. These latter include, among others, an aromatic variety of laurel, bay grape, and poison ivy. Trees in this area are of three types: palmettos, up to 12 feet high; casuarinas, up to 25 feet; and the smooth gray skeletons of cedars killed by a juniper scale blight in the 1950s.

While it is true that the wild foods available on Hall's Island cannot compare with the 8,000 varieties in the forests of Malaya as reported by Ellefson (1967), different observers agree that the gibbons in Bermuda obtain up to 50 per cent of their daily diet from the leaves, seeds, berries, buds, and flowers naturally occurring on the island. Rainwater is caught in rock "bowls" eroded in the bare limestone near the cliff's edge, but the water in these usually dries up after 2 or 3 days and must be supplemented artificially.

THE CLIMATE

The climate of Bermuda is semi-tropical and, overall, is very mild. The annual mean temperature is 70.2° Fahrenheit. The highest temperature ever recorded was 94.8°, and the lowest was 43°. The average high is 75.5°, the average low is 64.9°, and the mean daily range is 10.6 F degrees. The monthly overall mean varies from 61.7° in February to 80.0° in August (Macky, 1948).

The Bermudian temperatures compare favourably with those given by Ellefson (1967) in his description of the gibbon study site at Tanjong Triang, Malaya, where the annual mean temperature is 81°, with a maximum of 98°, a minimum of 71°, and an average daily range of 15 F degrees.

Comparison of rainfall data show Bermuda to be much drier than Malaya gibbon habitats. Bermuda's annual rainfall is 57.6 inches, with an all-time high of 89.6 inches and a low of 39.4 inches recorded. The annual rain is spread very evenly over the year, with monthly averages varying from 3.9 inches in April, to 6.4 inches in October. At least 0.01 inches falls on an average of 168 days per year, or just over 0.34 inches per rain day (Macky, 1957).

The rainfall at Tranjong Triang is 110 to 120 inches a year, or twice the Bermuda total. The Malayan rainfall is much more seasonal than in Bermuda, one-half the year's total falling in the monsoon months of November through February. During the year of Ellefson's (1967) study, his site received 127 inches of rain on 136 rain days, or 0.93 inches per rain day. Monthly averages varied from 0.7 inches in January, to 57 inches in December!

Bermuda lies in the Atlantic hurricane belt and on occasion receives winds of up to 60 or 80 miles per hour during tropical storms. Many rain showers bring winds of 40 to 50 m.p.h. The most recent serious storm was Hurricane "Alice," which rolled across Bermuda on the Fourth of July, 1973, bringing 6.5 inches of rain and winds of 65 to 75 m.p.h.

The gibbons on Hall's Island appear relatively undisturbed by wind or rain, and only in the most severe storms do they tend to seek shelter. Ordinarily, each animal assumes a sitting position on a branch of a cedar or a palmetto, closely faces the trunk of the tree, and takes the full force of the storm on its back.

MODIFICATIONS TO THE NATURAL SETTING

Modifications to the environment of Hall's Island have been kept to a minimum. Only those changes necessary to facilitate the aims of the research programme have been made. For example, no boat dock has been built on the island, so that visits by inquisitive passers-by will be discouraged. Instead, a cedar post has been cemented into the rocks at the only place convenient for a landing, and a float is anchored to the bottom of the sound 20 feet from the post. This arrangement has proved adequate for securing the small fiberglass outboard motorboat used to service the island, although landings in rough water can be hazardous. A large, easily readable sign is posted near the boat landing, and requests that boaters remain silent and well clear of the island.

An underwater electric cable was laid across the 250 yards which separate Hall's Island from the main shore. The cable terminates at a power transformer station located in one of the two buildings on the island. This building is a wood-frame shed of one storey, measuring 8 x 12 feet, and is sheeted with corrugated asbestos composite. The main room is air-conditioned. It contains a refrigerator for storing fruit and drinking water, a work bench, and a primate restraining chair. This is one of two work rooms, and it is also used for the storage of materials and supplies. The roof of the shed is a single plane surface, also of corrugated asbestos, which slopes toward a rain gutter. The gutter empties into a steel drum, assuring a constant supply of water for the animals even when the preferred water, caught in the rock bowls, evaporates.

The second major structure is an observation tower located at the highest point on the island. The lower portion of the tower is an enclosed, air-conditioned room housing all electronic and photographic equipment. An observation platform measuring about 4 x 4 feet is located 10 feet above the ground. The upper part of the tower is an open framework with palmetto thatch covering. Two masts with radio antennae extend 15 feet above the top of the tower.

Approximately 80 per cent of the island's surface may be viewed from the tower platform. At one time as much as 95 per cent was visible, but over several years, the shrubbery has grown in height and density. This growth is probably the result of the processes of seeding and fertilizing carried out by the gibbons when they eat, then eliminate, native plant seeds. The growth of the shrubbery has necessitated the cutting of progressively more extensive systems of footpaths so that observers on the ground may more easily maintain visual contact with the gibbons. The gibbons react to these pathways ambivalently, sometimes walking along them during terrestrial travel, sometimes swinging or jumping across them during arboreal travel.

A more important pathway modification is the suspension of 1000 feet of one-inch, braided nylon rope from cedar skeletons and bamboo frames. This forms two separate trailway systems; one to the north and one to the south of the centrally located tower. These trailways were erected to facilitate brachiation by the gibbons. Perhaps the greatest deviation of Hall's Island from a natural gibbon habitat is the dearth of tall trees with interdigitated, or at least closely adjacent, horizontal branches. The Bermuda gibbons have adapted very well to this situation, however, and the swingways are used extensively. Some individuals have established favourite routes over which they always travel when moving across specific areas.

Dr. Carpenter has referred to the system of ropes and cedars on Hall's Island as an "inverted forest." The dense ground cover on the island is seen as corresponding to the tall canopy of the Asian forest, with the nylon ropes corresponding to the main limbs and branches over which gibbons travel in their native forest habitats

(Carpenter, in press). It should be noted, however, that in a detailed analysis of gibbon behaviour, the "functional" inversion of the forest is not complete.

Two separate trail systems were set up in order to encourage the development of any tendency of the animals to form territories. This concept of accentuating the features of the island which might reinforce territorialism was carried over in the placement of screenwire enclosures or "compounds." There are three compounds on Hall's Island. Compound 1 is in the centre of the grassy area at the southern end of the island. It has a metal frame measuring 8 x 10 x 5 feet. Compound 2 has a wood frame of the same measurements and is located near the north-east shore. Compound 3 is near the central tower and has a metal frame measuring 6 x 8 x 4.5 feet. An animal feeding at one compound cannot see either of the other two. All of the compounds are maintained with *ad libitum* monkey chow and water so that each is potentially a centre for a territory.

All compounds have at least one large corner covered with marine plywood to serve as shelter from wind and rain, and two are fitted with pully-operated trap doors. Thus the compounds are well suited to a variety of uses. They may be used as holding cages for the recuperation of animals returned to the island after surgery or medication. They are used for acclimating new gibbon arrivals to the diet and weather of Hall's Island before releasing them onto the island.

The compounds are used to capture gibbons. The animals are habituated to entering the compounds as a result of receiving food and water in them daily. When it is necessary to handle an animal in order to service his electronics package, change batteries in a telemetry unit, or apply medication, it is sufficient merely to toss fruit into the compound of choice, wait for the appropriate animal to enter, then lower the trap door.

Finally, the compounds are used to sequester humans. When a gibbon is caught and handled, the others are likely to come to his defense, especially if he emits distress calls. Humans not inside the compound are likely to be attacked in these circumstances.

AIMS AND METHODS OF THE RESEARCH PROGRAMME

In the four years since the primate facility on Hall's Island first opened, the original concept of developing an animal model of small group interaction has evolved into a complex interdisciplinary programme with far-reaching implications. For example, the basic principle stated by Breland and Breland (1966), and accepted as a cornerstone of the Hall's Island project, goes ". . .you cannot understand the behaviour of an animal in the laboratory unless you understand his behaviour in the wild." This principle has a corollary which may be put: you cannot describe the effects of an experimental variable on the social behaviour of an animal unless you first completely describe the social behaviour of that animal in undisturbed adaptation to his present environment.

Thus it was first necessary to compile an "ethogram", or complete and systematic description of all individual and social behaviours of the gibbons on Hall's Island, implanted and non-implanted with brain electrodes. This work was first undertaken by two graduate primatology students under the direction of Dr. Carpenter in the summer of 1971 (Baldwin, in press). The method used was to report into an audio tape recorder a continuous narrative description of the ongoing behaviours of the animals. Hundreds of hours of such tapes were transcribed, summarized, and documented with both still and motion picture photography. From all this information was extracted a systematic set of behaviour categories for which rigorous definitions and descriptions were written.

With turnover of the gibbon population, ethograms are developed for new animals and the group ethogram is verified at periodic intervals in order to assess changes in behaviour that occur over time. As a result of this work, an archive of gibbon behaviour in photographs is being assembled.

Once the ethogram was relatively well developed, a "behaviour checklist" was devised, whereby the frequency of occurrence of the major behaviour categories is quantified. In its present form the checklist analyzes behaviour in terms of 5-second intervals. It records the location, motor behaviour, "purposeful" behaviour, and the social contacts of individual animals. Programmes are being written at the Research Center of Rockland State Hospital to analyze the checklist data by computer.

Studies of periodicities in gibbon behaviour, such as activity-rest cycles and diurnal rhythms, are aided by a Mobility Telemetric System (Gardner, 1971). This instrument, developed in Dr. Delgado's laboratories at Yale Medical School, provides for the continuous measurement of gross body movement in up to six subjects (monkey, gibbon, or human) simultaneously. The transmitter is a self-contained unit about the same diameter as a wristwatch and three times as thick. Gibbons wear the transmitters on a plastic harness much like a hiker's back-pack. Animals have worn these harnesses for up to four months continuously, usually with no irritation of the skin or other effects.

The mobility receiver is housed in the tower shed. It prints out numerical indices of mobility on paper tape at predetermined intervals which may be adjusted to between 3¾ minutes and 2 hours. Computer programmes have been written at Rockland State Hospital, New York, to summarize the mobility data and present them for numerical or graphical analysis. An automatic tape recorder interface is under development which will allow for the capture of mobility data on computer-compatible magnetic tape. The interface underwent field trials on Hall's Island in November 1973, and is expected to be operating full-time in 1974.

The goal of experimentally influencing the social behaviour of gibbons has also been approached with methods that are increasing in sophistication almost daily. Dr. Delgado is applying the method of radio-remote electrical stimulation of the brain that he pioneered in the 1960s (Delgado, 1964, 1965) as a standard method on Hall's Island. Using this technique, which eliminates the bother to the subject of carrying long connecting cables, Dr. Delgado has demonstrated in the laboratory that effective control of social rank and aggressiveness in monkey colonies (Delgado, 1967) and control of emotional states in humans (Delgado, 1969) is possible.

Modification of existing radio-remote stimulation equipment was necessary in order to adapt it to the stresses imposed by a freely-behaving animal in the corrosive island environment. Improved water-proofing methods were developed, antennae were more completely protected, etc.

The stimulator-receivers ("Stimoceivers") carried by brain-implanted animals are worn on the same harnesses as the mobility transmitters. The only problem encountered with the wearing of the stimoceivers is that existing models have a battery life of only nine days. This requires that an animal wearing one must be captured and handled at this interval. Batteries in the mobility transmitters have a life of 21 days.

In the summer of 1971 the peculiar problem on Hall's Island of poor radio-frequency-energy propagation at low power levels had not been solved. Animals were stimulated in a restraining chair, then released. Behaviour observations followed. With the installation of a newly-designed antenna system in the summer of 1972, the first remote stimulations of a truly free-ranging gibbon were carried out. Stimulation of nuclei in the limbic system and brain stem were programmed to occur repetitively for 15 minutes during a 45-minute narrative-observation period. Dr. Delgado will publish results of these studies elsewhere.

In 1973 another assessment technique was added to the growing arsenal of recording methods. Because intragroup aggression is infrequent in gibbons, the effects of programmed brain stimulation, designed to inhibit aggressiveness (and which works dramatically in the garrulous rhesus monkey), were often difficult to detect in the gibbons of Hall's Island. Dr. Carpenter has long recommended the use of measures of social-ordinal rank to determine dominance in primates. Feeding situations usually bring out dominance ranking behaviours, but again the gibbon is a special case, in that reciprocal food-sharing is often observed (Berkson and Schusterman, 1964). Eventually Dr. Carpenter and this author were able to work out a method which met the particular challenges of assessing ordinal rank in the gibbon in a free-ranging situation. A 3½ inch diameter section of bamboo was cut 6 inches from a node at one end, thereby forming a cup. An observer sequestered inside a compound placed a single piece of fruit in the bamboo cup and raised the pole up through a small opening in the top of the compound. The presentation of the baited cup was repeated at one-minute intervals while one or more observers outside the compound recorded the location and spacing of all animals, their interaction, and the identity of the animal taking the fruit. Since the cup in the end of the pole was large enough for only one gibbon hand at a time, competition, conflict, and even fighting were evoked in the animals.

When inhibitory stimulations were applied to the most dominant gibbon during these food tests, competitive behaviour decreased. The effects for at least some brain nuclei were much clearer than when the stimulations were applied in a "free-field" situation. Furthermore, food tests without stimulation provided a new means for assessing lasting or carry-over effects from previous stimulations. Of course, one of the main goals is to stimulate the same animals in the laboratory *and* in the free-ranging situation *while using identical assessment techniques in both*. This is now possible.

One more goal of the work on Hall's Island is to develop new techniques and methods which may have potential therapeutic applications for humans. Elsewhere, some progress in this direction has already been made with the application of electric brain stimulation to the treatment of some forms of epilepsy (Delgado *et al.*, 1968). Hall's Island will be an important proving ground for the testing of new stimoceivers, for example, as they are progressively made smaller in size and greater in effective range and reliability.

Plans for further development of the programme include the implementation of drug testing programmes. Nathan S. Kline, M.D., Director of the Research Center, Rockland State Hospital, New York, pioneered the use of pharmaceuticals in psychiatric treatment. In collaboration with Dr. Delgado, Dr. Kline is planning a programme of studies utilizing radio-controlled injection of chemicals directly into a specific brain nuclei through implanted cannulae. The aim is to develop a method to aid investigation of the effective site and mode of action of various psychopharmaceuticals. Such a system could also be used to test promising new drugs in a sophisticated animal model.

In another collaborative study with Dr. Delgado, Dr. D. R. Brebbia, also at Rockland State Hospital, proposes to investigate the effects of specific neurochemical agents on the electrophysiological and behavioural parameters of the sleep-wake cycle in the gibbon. The work would require the development of improved lightweight, multi-channel transmitters for the telemetry of the electroencephalogram (EEG). Engineers in Dr. Delgado's laboratory are working to develop such equipment. Under the direction of Dr. Kenneth Lifshitz at Rockland, programmes and instrumentation for the computer scoring of EEG records have been developed. The completion of the total system will eventually enable two-way communication with the brain of an unrestrained animal, thus opening whole new fields of research.

CONCLUSION

A programme with the diversity of the one now being conducted and enlarged on Hall's Island, Bermuda, requires a great deal of ancillary support in the forms of electronic laboratories, computer data processing facilities, surgical laboratories, veterinary care facilities, and much more. It remains, however, that the most important element in the programme is the *environment* of Hall's Island, uniquely designed to exploit the adaptive features of the gibbon, smallest of the anthropoid apes.

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What are the Variables Necessary for Training Environmental Designers?

Leonard Krasner[1]

My current task is to develop a programme to train environmental designers. A logical way to start a discussion of this topic would be to define the terms "programme" and "environmental designers." However, I shall save the definitions until the end and attempt at this point to place the genesis of this programme, as well as the effort of this conference, in historical perspective.

The reason for doing so is not merely out of a scholarly love of historical esoterica, but rather because I believe that the particular historical context is a major influence on the current behaviour of investigators. In effect, almost all of the investigators at this conference are working within a common paradigm, to utilize Khun's (1970) term. Part of our task is to determine the basic assumptions and consequences of this paradigm for research, for training, and for social application. A major argument to be made here, which is also one of the attributes of this model, is that research, training, and application are inseparable – they are fused together rather than being separate but related aspects.

We are presenting a theory of behaviour influence (Krasner and Ullmann, 1973), and a major aspect of this theory is that historical antecedents, paradigms, superstitious beliefs, and/or myths are major influences on the current behaviour of any investigator. The training of investigators partly involves making them aware of these influences and freeing them from the impact of these beliefs as much as possible.

We are part of an historic symposium on environmental research and its relevance to the study of problems of behavioural economics and social policy. It represents a coming together of streams of development in the history of those

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professions which specialize in research and application of social-behavioural principles that influence human behaviour.

Historical Context

Current work in environmental design (or, controlled environments, token economy, contingency management, and programmed environments) represents a merging of fields labelled behaviour modification, environmental psychology, open education, social reform, ethics, and social planning.

In a previous historical review of this field, I have suggested that at least 15 streams of development in research and application have merged to form the uneasy alliance presently called behaviour modification (Krasner, 1971). I will first deal briefly here with the developments in the field of behaviour modification which have most influenced the token economy and subsequent micro-environment approach.

There is the stream of instrumental or operant conditioning which can be traced back to Thorndike but is now most influenced by the research and philosophical views of B. F. Skinner (1938, 1971). At the risk of oversimplification, Skinner's views can be summarized as the observation and hypothesis that behaviour is a function of environmental consequences; a behaviour followed by positive consequences is more likely to reoccur. A mighty research empire has been built upon the simple observation that behaviour is determined by its consequences and that a positive event increases the probability of reoccurrence.

The publication of Skinner's *Walden Two* in 1948 was a remarkable event in that it represented a scientist foretelling, and to some extent influencing, the logical social consequences of his research. *Walden Two* posed and attempted to answer the kind of question which we are dealing with in this symposium. It involved the nature and economic organization of society required to bring about specific desired behaviours. Other writers, of course, for example Plato and Sir Thomas More, tackled this problem previously. But Skinner approached it in the context of the deliberate application of a set of hypotheses and principles about human behaviour derived from the experimental animal laboratory. Also, he did so before there had been any experimental applications to human problem behaviour.

Probably the first such application appeared in the work of Fuller (1949) who operant-conditioned arm-raising in a "vegetative idiot" (by definition a non-conditionable organism).

An important development in the operant conditioning stream was the work of Lindsley and Skinner (1953) with psychotic patients in Metropolitan State Hospital in Boston. Another came with the observations made in a Canadian mental hospital by Ayllon and Michael (1959) that the crazy behaviour of patients was actually maintained by the consequences of staff reaction (reinforcement). The work of Bijou and his colleagues at Ranier State School for Retardates, where the first token economy programmes in classrooms were developed, provides yet another important example.

Ayllon and Azrin (1965) developed the first token economy programme in a state mental hospital on a ward with "psychotic" females. I was involved in the second such programme (Atthowe and Krasner, 1968; Krasner and Atthowe, 1971) in a Veterans Administration Hospital in Palo Alto, California. Following these two programmes, there was an enormous spurt in the use of token economy programmes in state hospitals, in Veterans Administration hospitals, and eventually in other community institutions such as the home, school, prisons, and the armed services. For recent reviews, see Kazdin and Bootzin (1973).

Others of the 15 streams include the two independent developments of the term "behaviour therapy." One evolved from the work of the investigators at Maudsley Hospital in London in the early 1950s. The emphasis of this group was on the application of "modern learning theory" to problems or "maladaptive" behaviour. Learning theory at that time referred primarily to the work of Hull and to the conditioning principles of Pavlov. The work of investigators such as Shapiro, Jones and others was categorized as "behaviour therapy" in 1959 in a paper by Eysenck, who was the Director of the Maudsley Psychology Department throughout this period.

Another independent development of behaviour therapy grew out of the work of a South African psychiatrist, Wolpe (1958), which was labelled as behaviour therapy in a paper by a student of his, Lazarus (1958).

All three of these initially independent streams, influenced by Skinner, Wolpe, and Eysenck, had in common an emphasis on working directly to change undesirable behaviour and to elicit a more adaptive or socially desirable behaviour in the individual.

However, for our purposes on this occasion, perhaps of greatest importance was the development of models of behaviour, normal and deviant, as alternatives to the generally accepted disease model of psychopathology (Ullmann and Krasner, 1965, 1969). Here indeed we are witnessing a paradigm battle and perhaps a shift from one to the other in general acceptance.

It is this newer model of behaviour, whether it be called behaviour modification, social learning (Bandura, 1969), sociopsychological, or behaviour influence (Krasner and Ullmann, 1973), which offers a solid theoretical rationale to the economic environmental research presented at this conference.

My own interest in the economic area developed gradually as I began to realize that the real goal of a token economy was to plan an environment in such a way that the proposed goals were likely to be realized. Then came the further realization that in this sense there was nothing unique about a token economy. It was in fact an attempt to reproduce systematically what happens in "real life" every day in every setting.

At a CIBA conference in London in January 1968, in evaluating the direction of token economy programmes, I noted that:

> . . .token economy procedures need a combination of social and economic planning. When an economist (for example Galbraith, 1967) relates a 'general theory of motivation' to the economic structure of society, he is presenting hypotheses that can be tested in small social units, such as hospital wards, by means of a token economy. The research potential of the application of behavioural principles to social affairs is enormous and represents the next stage of development in the application of learning to psychotherapy. (Krasner, 1968)

Thus we begin to see the investigation of behaviour modification merging with economic theory and token economy. The pioneering work in this area comes from Robin Winkler's (1971, 1972) dissertation studies at New South Wales which developed from within the behaviour modification influences and the work of Kagel (1972) and the group at Texas A & M (Battalio *et al.*, 1972, 1973). There is a whole body of research in the field of economics on which I do not have the background to comment other than to point it out and wonder about the relationship between the classic economic theory and Galbraith's ideas, and the implications of either or both for application to micro-environmental studies.

Another major investigative development is environmental psychology. The roots of this movement lie in social, experimental, and clinical psychology; major influences come from workers of quite diverse backgrounds: Wohlwill, Craik, Binder, Willems, Proshansky, Altman, and Sommer. A significant impetus to the field was the 1966 *Journal of Social Issues* on "Man's Response to the Physical Environment." The particularly useful paper of Studer and Stea (1966) linked the notions of environmental design and architectural programming.

Altman (1973) has presented the four major models of man that have influenced the work of the environmental psychologist. These are the mechanistic; perceptual-cognitive-motivational; the behavioural; and the social systems-ecological. All of these are important in understanding where environmental psychology stands today and its linkage with these other fields.

Another development relevant to our concern with training environmental designers is that of open education. In fact research in this field has had a major impact on my own thinking. We do not have enough time to explore this development fully, but see Krasner and Krasner (1973) for the linkage between open education and the concept of planned environments. Simply put, the notion is that the classroom is an environment in which the teacher is the designer or planner of the environment. We feel that this is always true of any classroom. The attraction of the open classroom is that the teacher moves more clearly into this role by virtue of having to use his/her experience and ingenuity in planning twenty-five individual environments. In the training programme we are leading up to, we have selected the open classroom as the most useful kind of environment in which students can observe and learn environmental design. In part, this is so because the more open approach to education is in a developing stage, and students can observe the process and influence it. Further, it is a process which closely links valued behaviour or behavioural objectives (which is another way of saying social implications) and the design of the environment to achieve the objectives. More and more, the teacher realizes that he/she must talk in terms of goals and purposes for every design or feature incorporated into the environment. Put another way, the teacher forces him/herself to do a functional analysis of behaviour.

Training the Environmental Designer

We started by saying that our goal was the development of a programme to train environmental designers. One purpose of such a programme is to help a small segment of Ph.D. clinical psychologists to reconceptualize their task of aiding others in terms of helping people learn how to design, influence and control their own environment. In order to do this their model becomes educational, rather than medical; the aim is not to treat sickness but to train people to help themselves. This programme also allows observation of what is happening to the behaviour of some clinical psychologists as it is being developed. In effect, we would like to accelerate this development.

A second purpose is to develop a professional environment designer at a Bachelor's and/or Master's level who will be able to work in a variety of settings such as schools, hospitals, community mental health centres, prisons, universities, addiction centres, and similar social institutions where he or she can bring to bear his or her value system and technology to serve as advisory or practising consultants to train people to influence their own environments. These environmental designers should work very closely with the Ph.D. clinical psychologist in facilitating and effecting change in individuals and institutions.

In part, this historical review answers a portion of my initial question. To train environmental designers, we should expose them to theory and research in behaviour modification, environmental psychology, architecture, open education, technique of training, economics, social planning, values and ethics, planned societies (such as utopias and communes), law, social organization, and to practical matters such as carpentry, cooking, and plumbing.

The major vehicle for the training programmes at present is a seminar jointly attended by a) graduate students in clinical psychology who are being trained in the instruction of environmental designers and b) undergraduate students who are being trained for a job or graduate study in this emerging field.

As part of our environmental design seminar, we have readings, discussions, and visitors talking, on such topics as: environmental design as an extension of behaviour modification; the classroom as a planned environment; research as both an environmental design and a behaviour influence; the token economy as a planned environment; economic principles as influences in the classroom, in the mental hospital and in society; the architectural arrangement of space as an influence on behaviour; the social role of behaviour-change agent; the occupational career of environmental designer; social and ethical implications of environmental design; the consequences of demography on planning environments; and environmental design of the community. The last mentioned refers to the design and function of community mental health centres; planned societies or people designing their own environments; and also to civil liberties, social justice and other worthy goals of environmental design.

Admittedly, this is a broad range of topics and material, yet I feel that these are but a start in the examination of what variables must be considered for training professional environmental designers. We should also note that these students in the seminar are serving as participant-observers in open classrooms in our local school system. Their task is to observe how the teacher plans his or her environment, including how the participant-observer is used.

Our aim is to develop a general approach to training people involved in designing environments that can be utilized in any social setting, be it a school, a hospital, a community centre, or a home.

We are in the process of developing a series of courses for individuals whose research and orientation are compatible with the social learning orientation of this programme. These include sociologists, political scientists, historians, economists, marine biologists, as well as psychologists.

There is, however, one problem which I will only mention at this point. Is a programme such as this socially desirable? Should society train a specific group of individuals as professional "designers of environments"?

A major point which derives from the social psychological or social learning model is that the goal of helping individuals is to enable them to learn how to control, influence, or design their own environment. Implicit in this is a value judgment that individual freedom is a desirable goal and the more an individual is able to affect his environment, the greater is his freedom. Of course, there is no absolute freedom in this sense. I should make clear that what I mean by "environment" is both the people and physical objects in one's life.

In dealing with people, we are involved in an influence process that is ubiquitous, not a process of curing or helping unfortunates.

By this model, everyone is involved in designing environments: the individual who seeks help, the therapist, the researcher, the school teacher, the parent, the student, the warden, the planner of conferences on planned environments. My original question, how to train the environmental designer, could be interpreted to mean, "how to train people to live in our society."

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